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GUNNER'S MATE 1 & C

NAVY TRAINING COURSES

NAVPERS 10186

GUNNER'S MATE

1 & C

Prepared By

BUREAU OF NAVAL PERSONNEL

NAVY TRAINING COURSES

NAVPERS 10186

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1954

J.S.S.D.

PREFACE

This course is designed to help you earn promotion to the rate of Gunner's Mate First Class, or Chief Gunner's Mate. Study of this course will help you to pass the written examination that you must take in order to attain either of these rates. Other materials that you may find it valuable to study along with this course are mentioned in the Reading List that appears on the page following this preface.

In Appendix II at the end of this book are printed the present *Qualifications for Advancement in Rating* as they apply to the Gunner's Mate. (Check also with the current edition of the qualifications as published in NavPers 18068.) Use them as a guide in your studying. Although this course, with the others in this series, is primarily intended to take up examination subjects, you will find that it gives you valuable background information in connection with the practical tests that you must also take to earn promotion.

Whether you are working toward either your First-Class or CPO rate, you will find it wise to study this entire course. However, as you can see from the *Qualifications for Advancement in Rating*, you will want to concentrate on certain topics for GM1, and on others for GMC. A Study Guide (on another page at the front of this book) shows which chapters you should hit especially hard, depending on which rate you're working toward.

As one of the NAVY TRAINING COURSES, this book has been prepared by the Navy Training Publications Center for the Bureau of Naval Personnel, with technical assistance by the Advanced Gunner's Mate School, Naval Receiving Station, Washington, D. C.; by the Bureau of Ordnance; and in chapter 5, by the Naval Powder Factory, Indian Head, Md.

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READING LIST

NAVY TRAINING COURSES

Gunner's Mate 3, NavPers 10181
Gunner's Mate 2, NavPers 10184
Basic Electricity, NavPers 10086
Basic Machines, NavPers 10624
Basic Hand Tool Skills, NavPers 10085

OTHER NAVY PUBLICATIONS

BuOrd Manual (1955), Chapters 1, 4, 8.3, and 11.1
Ammunition Handling, NavPers 16194
Naval Ordnance and Gunnery, Vol. 1, NavPers 10797–A Chapters 10, 11, 13, 14 (less Section E)
Naval Ordnance and Gunnery, Vol. 2, NavPers 10798–A (Chapters 18, 21, 22, 29, 30, 31)

USAFI COURSES

United States Armed Forces Institute (USAFI) courses for additional reading and study are available through your Information and Education Officer.[1] A partial list of those courses applicable to your rate follows:

Number	Title
B 769	*Introduction to Mechanical Drawing I*
B 779	*Blueprint Reading*
B 781	*Fundamentals of Electricity*
C 836	*Machine Shop II*

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[1] "Members of the United States Armed Forces Reserve components, when on active duty, are eligible to enroll for USAFI courses, services and materials if the orders calling them to active duty specify a period of 120 days or more, or if they have been on active duty for a period of 120 days or more, regardless of the time specified in the active duty orders."

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STUDY GUIDE

Chapter	Title	GM1	GMC
1	Sources of information		X
2	Maintenance, repairs, and alterations	X	X
3	Electricity for the Gunner's Mate	X	X
4	Fire control	X	X
5	Smokeless powder		X
6	Hydrostatic depth charges	X	
7	Influence-type depth charges	X	
8	Rockets, launchers, and projectors	X	
9	Mines and aircraft bombs		X
10	Ordnance supply	X	X
11	Demolition materials and techniques	X	
12	Battery alignment	X	X
13	Safety	X	X

Note to Student: The purpose of this Study Guide is to indicate to you which chapters in this course are MOST concerned with the items in the *Qualifications for Advancement in Rating* that pertain respectively to GM1 and GMC. When you study this course, concentrate on the chapters indicated for the rate toward which you are working. But don't just ignore the other chapters. If you're working toward GM1, remember that you want to be a Chief some day; if you already are a First-Class Gunner's Mate and are preparing for your Chief's exam, you'll find that you can probably use a complete review of the course. And, finally, remember to review the earlier courses in the Gunner's Mate series.

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GUNNER'S MATE
1 & C

Reprinted with minor changes 1960

CHAPTER 1

SOURCES OF INFORMATION

INTRODUCTION

Mission of This Training Course

This training course is meant to help you advance in rating to Gunner's Mate First Class or Chief Gunner's Mate (depending on the rate you now hold). Briefly, it contains the fundamentals of what you should know in order to perform the duties of these two rates. It outlines those duties, shows how they fit into the larger picture of the Navy's operations, explains the responsibilities of men in these rates, describes the ordnance equipment involved that has not been taken up in the earlier courses in this series; besides all this, it shows you, as a candidate for GMC or GM1, not only what further information you will need to meet the qualifications and hold down the job, but also (as far as possible) how you can get it.

The Gunner's Mate job is a big and highly diversified one. No one book like this one can contain everything there is to be said about it. This is true for two main reasons. One is that much of the job depends on "know-how" that you can develop only through actual experience, and no book or group of books is an adequate substitute for experience. The ordnance maintenance skills you now have came from working on ordnance gear, and you must continue to retain and develop your skills that way.

The second reason that we cannot get all you need to know about the job between a set of book covers is that there is so much to it. The current edition of the *Manual of Enlisted Navy Job Classifications* (NavPers 15105) contains 23 different definitions of jobs (or groups of jobs) under the heading "Gunner's Mates," each requiring different skills and knowledge (though there is a lot of overlapping, too). And it will be evident, by the time you get to the end of this chapter, that the Gunner's Mate (especially First or Chief) is concerned with a great deal more printed material than one might think. So this book will contain many references to other sources with which you will have to be familiar in order to know your job.

Military Leader and Technical Specialist

You know that as a Navy petty officer you are both a military leader and a technical specialist. In your work, of course, these two phases go together. As a petty officer, you have certain general or military duties, and as a specialist, you have certain professional or technical duties. And you are responsible for attaining proficiency in both phases of a petty officer's work. This should be nothing new to you. It is repeated here only because this book, like the others in this series, is NOT concerned with general or military duties. This book takes up only your specialist or technical (professional) duties. For your military duties, you should study the *Military Requirements for Petty Officers 1 & C*, NavPers 10057.

Practical Factors and Examination Subjects

You know also that you must qualify for advancement both with respect to PRACTICAL FACTORS, on which you are tested by performance on the job, and EXAMINATION SUBJECTS, on which you are tested by written examinations. Now, although no book—not even this one—is an adequate substitute for the practice that makes for proficiency in performance, this book, or those cited in it as references, can give you background information that will help you learn more quickly and make you more efficient in the performance of practical work. To the extent that is feasible in this way, then, this book can help you with respect to practical factors.

With respect to examination subjects, this book can give you even more substantial help. What you must do is study these pages and those of the references, and make their contents part of you. No detailed study plan is offered here; as a candidate for GMC or GM1 you should know by now what to learn and how to study and organize what you learn (as well as what areas you especially need study in). Turn to the appendix and read over the qualifications. This book was designed specifically to prepare you to meet those qualifications; you can use them as your guides in planning your study program. This book is based particularly on those qualifications that apply to Gunner's Mate First Class and Chief, but you are responsible also for reviewing the material applicable to lower rates.

And now let us take up the published sources of information you should be familiar with as a GMC or GM1.

PUBLISHED SOURCES OF INFORMATION

Both the men under you and the officers over you will depend upon you, as Chief Gunner's Mate or (though to a somewhat lesser degree) as GM1, to be the principal source of technical information and advice on the weapons and related ordnance gear aboard your ship. The rating badge on your sleeve means that you know your stuff.

To a great extent, your technical know-how depends on your experience. But much of that know-how (and even more of what we can here call "know-what") will have to come from printed sources of information. This doesn't mean that you're expected to memorize OP's and OCL's; it does mean that you are expected to be able to get the information—quickly. Getting the information, in turn, means (1) knowing just which book, pamphlet, or other source contains it, and (2) having that publication on hand. To know what publication contains the information you need, you must be acquainted with the whole range of publications on ordnance, and with the specific publication to which you will refer. To have the necessary publications on hand, you must know where and how to get them, and how they are distributed.

In succeeding articles we shall discuss the published sources of ordnance information, how you can find out what they contain, and how they are distributed. Let us first take up those published by the Bureau of Ordnance.

Bureau of Ordnance Publications

The publications of the Bureau of Ordnance are listed below. Only the *Bureau of Ordnance Manual* is the title of a single book; the other designations represent groups or series of publications. In the OP series, an individual item may range from a 2-page leaflet to a set of six fat bound volumes. The list indicates also the publication in which the items of each series are listed or indexed.

Title or Designation	*Short Title or Abbreviation*	*Index*
Ordnance Pamphlets	OP	OP 0
Ordnance Material Letters	NavOrd OML	OP 0
Ordnance Handling Instructions.	NavOrd OHI	OP 0
Ordnance Alterations	NavOrd OrdAlt	NavOrd OrdAlt 00
Bureau of Ordnance Manual	(none)	(none)
Ordnance Circular Letters	NavOrd OCL	OP 0
Ordnance Data	NavOrd OD	OP 0
Ordnance Allowance Lists	NavOrd List	NavOrd Lists 0 & 00
Ordnance Standards	NavOrd OSTD	NavOrd OSTD 0
Ordnance Specifications	NavOrd OS	(none)
Ordnance Reports	NavOrd Reports	NavOrd Report 0
Ordnance Charts	NavOrd Chart	OP 0
Bulletins of Ordnance Information.	NavOrd Info	No. 1 of each volume.
Bureau of Ordnance Drawings.	(none)	Bureau of Ordnance List Sketches
Bureau of Ordnance Line Sketches.	(none)	(none)
Registered Ordnance Pamphlets.	ORD	RPS 6
Bureau of Ordnance Forms	NavOrd Form	OP 0
Army publications describing Army ordnance equipment used by the Navy.	(Army Symbols)	OP 0

Ordnance Pamphlets

The primary source of technical information on operation, maintenance, adjustment, installation, and servicing of ordnance gear is the Ordnance Pamphlet (OP) series. These are published by BuOrd, each under its own OP number, but they may be prepared by some other naval activity (such as the Naval Weapons Plant), by the manufacturer, by a commercial specialist in such publications, or by the Bureau of Ordnance itself. OP's dealing with ordnance equipment are organized according to the following general outline:

Introduction
Theory and functional description
How to operate
Physical description
Installation and assembly
Maintenance
Overhaul and repair
Appendixes
Index
Safety precautions

In the introduction you will find a brief explanation of what the equipment is, where it is used, what it is intended to do, and the like, as well as a description of the differences among various marks and mods, if appropriate.

Normally one chapter is devoted to each heading, though with complex equipment (like the 6-inch RF dual-purpose turret of the *Worcester* class) each topic may require an entire volume. Or, if the OP takes up a different assembly or subassembly in each chapter, the outline may be followed, so far as it is applicable, in the individual chapters. So there are variations, but the topic list above, or one much like it, is used by OP writers as their checklist; it shows what information you can expect to find in standard OP's on equipment, and approximately where to find it.

Some OP's (for example, OP 4 on ammunition) take up a subject matter AREA rather than a specific item of ordnance gear; such OP's of course do not follow the standard outline above.

OP's and all other BuOrd publications may be issued under any security classification from Top Secret down to Unclassified, and are subject to the standard regulations regarding security. All Top Secret and Secret publications are REGISTERED—each copy bears a serial number and is loaned to the authorized person only in exchange for the proper receipt. Publications of lower classification may bear a register number, depending on whether or not strict accountability for each copy is to be maintained. When registered, any BuOrd publication becomes an ORD and bears an ORD number assigned by BuOrd.

OP 0 (zero) is the official list of OP's and of several other publications dealing with ordnance. OP 0, which is revised and reissued annually, consists of two sections. The front section lists publications numerically and indicates for each pamphlet its exact title, date of issue, security classification, cancellation notes, number of changes issued, and certain other information. The second section serves as an alphabetical topic index covering the publications listed by number in the first section. Registered publications, by the way, are listed not in OP 0 but in RPS 6.

One other OP that serves as a guide to BuOrd publications is OP 1, *Preparation of Ordnance Publications*. This pamphlet describes the types of publications in the BuOrd publication system, including their purpose and format, and how they are amended. It also explains in detail how manuscripts and illustrations are prepared, and contains other technical details of interest to those responsible for issuing these publications.

Most OP's are fairly massive publications; some require several volumes. Their preparation is costly in terms of both time and money. So, when one is issued, it's likely to be a rather long time before it can be replaced by a revised edition.

But ordnance gear is changing all the time, and the OP's on every item of ordnance gear must be kept up to date. This is done by issuing CHANGES. A change is a leaflet or pamphlet that specifies in detail actual text alterations in the OP to which it applies. Changes are issued automatically in the same distribution list that applies to the OP concerned. When received, the change should be attached inside the front cover of the OP, and the text and illustration alterations called for should be entered promptly in the OP itself.

Ordnance Material Letters

Though changes to OP's make it possible to amend OP's without going through all the motions of complete revision and reissue, there is still needed a publication that can be used for getting out the word rapidly on technical instructions and information regarding ordnance gear. This is the NavOrd OML, or Ordnance Material Letter. (A few years ago it was customary to use Ordnance Circular Letters (OCL) for this purpose. OCL's have since been limited to other uses, and those that contain such technical matter will eventually be canceled and not replaced.) OML's contain information concerning manufacture, production, procurement (including inspection for procurement), assembly, installation, operation, maintenance, overhaul, repair, alteration equivalent to repair, and disposition of ordnance material.

NavOrd OML's are issued by BuOrd in eleven series, each series applicable to a certain subject matter area. The eleven series are:

A.—Ammunition and pyrotechnics
C.—Chemical warfare equipment
D.—Degaussing
E.—Depth charges
F.—Fire control and optical equipment
G.—Guns, mounts, torpedo tubes, and missile launchers
M.—Mines
N.—Nets and booms

T.—Torpedoes
V.—Aviation ordnance equipment
X.—Miscellaneous material not covered by the above

(NOTE: NavOrd OML's will replace OMI-V's, which were used for ordering simple modifications of aviation ordnance equipment until OML's were introduced during 1950. For further information on modification instructions for ordnance equipment, see the discussion on OrdAlts, below.)

OML's are consecutively numbered within each series for each calendar year. (Example: NavOrd OML G3–50.) But where one OML involves more than one type of ordnance material, combinations of series letters may be used. (Example: NavOrd OML AV3–51.) OML's are listed in OP 0 editions of 1951 and thereafter.

Ordnance Handling Instructions

Ordnance Handling Instructions, or NavOrd OHI's, are instructions in card or tag form for the use, care, and installation of newly issued equipment. They are issued by the Bureau of Ordnance, and are ordinarily attached to the equipment or included in its container. Like OML's, they are issued in several lettered series, but the lettering system is a little different. Here it is:

A.—Ammunition and pyrotechnics
C.—Chemical warfare equipment
F.—Fire control and optical equipment
G.—Guns and mounts
M.—Mines and depth charges
N.—Nets and booms
T.—Torpedoes and torpedo tubes
V.—Aviation ordnance equipment
X.—Miscellaneous material not covered by the above

OHI's in each series are numbered consecutively, with the series numbers starting over again each calendar year, as with OML's. They are not used for long, detailed instructions, and should not be considered as substitutes for OP's.

Ordnance Alterations

The publications discussed so far (with one exception—the OMI-V) have to do with installation, operation, maintenance, and so on, of ordnance material, but not with any changes that must be made to ordnance material from time to time, for one reason or another. At the same time, such changes must be made uniformly, so that all items of a given type will continue to conform to standard specifications of performance and interchangeability.

When changes must be made to ordnance material already in the hands of the Fleet, they are usually made by means of a publication called an ORDNANCE ALTERATION (symbol: NavOrd OrdAlt). OrdAlts are numbered serially, and are classified not only by security level but also by priority as either Urgent or Routine. They are issued only to ships and other activities which have in active service the items affected by them. OrdAlts are more than mere sources of information; they constitute a basis for requisitioning materials required by the alterations involved. OrdAlts are listed in NavOrd OrdAlt 00, *List of Alterations to Ordnance Equipment for All Classes of Vessels, Aircraft, and Shore Stations*, which also indicates their current status; you will not find them in OP 0. For further information on OrdAlts, including reporting of completed alterations, see chapter 2 of this course.

Alterations which are extensive enough to modify materially the military characteristics of a ship are authorized by CNO, and are issued as NavAlts by the technical bureau having cognizance over the equipment concerned. The Bureau of Ordnance issues those NavAlts that deal with ordnance equipment, and they are listed under both OrdAlt and NavAlt numbers in NavOrd OrdAlt 00.

Policy Publications

Two other BuOrd publications might aptly be termed "policy publications." They are the *Bureau of Ordnance Manual* and the Ordnance Circular Letter.

The *Bureau of Ordnance Manual* "is issued to provide uniform procedures insuring accurate and expeditious performance of work under the cognizance of the Bureau." It also contains the official statement of the organization and duties of BuOrd, and a great deal of basic information on ordnance maintenance and nomenclature. It is issued under the authority of SecNav and legally "has the full force and effect of Navy Regulations." It is amended by publication of changes.

Ordnance Circular Letters (NavOrd OCL's) are "issued over the signature of the Chief of the Bureau [of Ordnance] to announce Bureau policy matters of general interest which, because of their temporary nature, are not suitable for inclusion in the *Bureau of Ordnance Manual*." As was brought out earlier in this section, OCL's were used in the past for promulgating technical information, but the preceding sentence describes present policy in their publication. They are issued in nine series, coded by letter (using the same system as OHI's), and numbered consecutively by calendar year. When all or part of an OCL is superseded by another OCL, the older issue is cancelled in its entirety; the portion remaining in effect (if any) is repeated in the new issue. In general, OCL's and other BuOrd publications specify which previous issue they supersede. OCL's are listed in OP 0.

Ordnance Data

Ordnance Data (NavOrd OD's) are a kind of catch-all. They are used for publishing advance information or instructions on ordnance equipment, installation and alignment data, parallax data, and other miscellaneous information, such as tables of weights and dimensions. Ordnance equipment lists are also issued as OD's. Formerly, OD's were used for publication of test and inspection data; Ordnance Reports are now used for this purpose. OD's are numbered consecutively by the issuing agency (BuOrd); their numbers do not overlap those of OP's. OD's are listed in OP 0.

Note the distinction between the standardized EQUIPMENT

LISTS published as OD's, and the Bureau of Ordnance Allowance Lists (NavOrd Lists) issued by the Ordnance Supply Office in the Naval Supply Depot, Mechanicsburg, Pa., under the direction of BuOrd and BuSandA. Equipment lists show the ordnance items to be installed in one ship or one class of ships by the shipbuilder; the NavOrd List covers all items to be carried aboard after the date of commissioning, and may be used as supply authorizations. You are not likely to have much to do with equipment lists on your ship; they are used mostly by BuOrd and BuShips for planning, and by the shipbuilder for guidance. For further detail on the NavOrd List, see the chapter on supply.

One OD that is required reading for you, and for all other Gunner's Mates, is OD 3000, *Lubrication of Ordnance Equipment, Including Power Transmission (Hydraulic) Fluids, Recoil and Related Fluids, Cleaning and Preserving Materials, Miscellaneous Materials, and Their Uses*. It is the one OD that your ship's library of ordnance publications must not be without. Other OD's may be useful to you, depending on the type of ship you are aboard, and its armament, but for that information you should consult OP 0.

Other Ordnance Publications

Ordnance Standards (NavOrd OSTD's) and Ordnance Specifications (NavOrd OS's) are both of primary interest to manufacturers of ordnance material and to storage facilities. OSTD's set forth Bureau of Ordnance practices that have become standardized, and serve as a guide to BuOrd Standard methods of design, drafting, and manufacture. OS's prescribe manufacturing requirements for specific items of ordnance material. In general, you will not have much need for these two publications on shipboard. One OS that may be useful for reference purposes is OS 3405, which prescribes the standard colors and painting specifications for Navy gun projectiles.

Ordnance Reports (NavOrd Reports) are research materials. They describe the methods and results of ordnance research projects. You will deal with these on shipboard only if your gear is undergoing some sort of test or research project; the reports are not ordinarily distributed to the Fleet.

Ordnance Charts (NavOrd Charts) are visual aids for instruction of officers and enlisted men in the understanding and use of ordnance equipment. They present enlarged phantom, sectional, and other views, often in color, of ordnance material and its components, which make for better understanding of its functioning. They are issued in nine series (using the same system as OCL's and OHI's).

Bulletins of Ordnance Information (NavOrd Info) are issued periodically for the information of naval activities both afloat and ashore. They are indexed in the NavOrd Info 0 issued each year.

Bureau of Ordnance drawings and sketches applicable to the ordnance equipment on any ship are automatically supplied when the equipment is installed, and should be so filed that they will be accessible when needed.

In addition to these, certain registered publications are prepared by BuOrd and issued to the service through RPS. These will be discussed further in a later section of this chapter.

Besides all these, the Bureau of Ordnance issues NavOrd Instructions and NavOrd Notices under the new Navy directives system, which is described in SecNavInst 5215.1, 19 May 1952. Issues published under this system have subject classification numbers; subjects relating to ordnance have numbers from 8000 to 8999. Some of the publications mentioned above will eventually be supplanted by the issues brought out under this new system.

Army Ordnance Publications

There is one other type of publication distributed to naval activities by BuOrd that you should know about. These are not BuOrd publications. They are Field Manuals, Technical Manuals and certain supply publications, issued by the Army for Army ordnance equipment. As you know, the Navy uses a great deal of such equipment—particularly small arms and light machine guns (and their ammunition). (Likewise, the Navy uses much aircraft armament in common with the Air Force, but you will not have much concern with such armament.) These publications are all cataloged in OP 0, and are issued to the naval service in the same manner as OP's. The principal types of Army ordnance publications with which you will deal are:

1. FIELD MANUALS (FM's). These are issued in different series. Each FM is designated by a two-part number; the first part is the number of the series, and the second is the identifying number of the pamphlet within the series. Nearly all the FM's you will use are in the 23-series. Each of these is about a specific weapon; FM 23–41 for instance, takes up the caliber .45 submachine guns M3 and M3A1. FM's in the 23-series take up operation and elementary maintenance of the weapon early in the book; the later sections have to do with marksmanship, target practice, elementary fire control (for high-trajectory weapons like mortars), and elementary tactics in the employment of the weapon in action on land. FM's are amended by changes.

2. TECHNICAL MANUALS (TM's). There is a large variety of these published by the Army, each on some specific subject matter area or type of gear. They are issued in numbered series under a system similar to that for FM's. Most of those that are distributed through the Bureau of Ordnance deal each with a specific item or type of gear—usually a weapon—though a few deal with subject matter areas such as chemical warfare or renovation of ammunition. Most of those you will encounter in your work are of the 9-series (ordnance), and take up the maintenance, disassembly, reassembly, adjustment, and installation of specific weapons or other ordnance gear. Like FM's, TM's are amended by changes.

3. TECHNICAL BULLETINS (TB's). These are used for rapid-fire dissemination of technical information, in much the same manner as OML's, though they have also been used to disseminate advance notice of changes to Technical Manuals. They are usually designated by three-part,

elaborate-looking numbers, but the system is fundamentally simple, since such numbers are based on those of the corresponding TM or group of TM's. Most of the TB's issued by the Navy actually accompany the TM's to which they apply. TB's not related to TM's are published under serial numbers with a symbol denoting the branch of the Army which issues them—for example, Ord meaning Ordnance Corps, or CW meaning Chemical Corps. No changes are issued on TB's; they are superseded or canceled by other TB's or by TM's.

The list of FM's, TM's, and TB's in OP 0 includes only those issues that are stocked and distributed by Navy agencies. There are many others, which are at the present time listed in the Army's Special Regulations, SR 310–20–3 and 310–20–4.

4. TECHNICAL ORDERS (TO's). Technical Orders are Air Force publications, and those listed in OP 0 deal with aircraft armament. You will not ordinarily have much occasion to deal with them.

5. STANDARD NOMENCLATURE LISTS (SNL's). These constitute the body of the Army ordnance supply catalog. Those that are available to naval activities are listed in OP 0. Each SNL consists of a pamphlet or group of pamphlets pertaining to a given type or model of Army ordnance material (including ammunition), and is designated by a letter and a number. The SNL pamphlets with which you are particularly concerned are those containing parts lists for the Army weapons or ammunition issued to your ship. SNL's issued through the Navy are listed in OP 0.

6. SUPPLY BULLETINS (SB's). These bulletins are used to promulgate supply information on Army ordnance material; those that are issued through the Navy deal with ammunition for Army weapons—its identification, grades, and information on safety.

7. ORDNANCE SAFETY MANUAL, ORD M 7–224. This pamphlet does not supersede the Navy's *Safety Precautions* or other official publications on ammunition handling and safety measures, but it is a useful guide.

Publications of Other Bureaus

You know that the Bureau of Ordnance is not the only source of the publications you need in order to function as a leading petty officer in the gunnery department. For one thing, the military aspect of your job requires you to be up on the publications that bear on that aspect, from *Navy Regulations* down. And, as a professional or technical specialist (which is the phase this course is concerned with), you are responsible for getting the word on supply work, on communications and other engineering department equipment, on the training of your men, and on combat and firing doctrine. In this section, we shall take up the more significant sources of information in these areas.

One of the broadest groups of publications that you will find useful to you (outside of those taken up earlier in the chapter) is that issued by the Bureau of Naval Personnel. This course is one of that group. Here is a checklist, arranged alphabetically by title, of those now available that you will most frequently find useful. Note that some of these (designated by an asterisk) are textbooks intended for officers' use.

Ammunition Handling, NavPers 16194
Basic Hydraulics, NavPers 16193
Basic Machines, NavPers 10624
Blueprint Reading and Sketching, NavPers 10077-A
Basic Electricity, NavPers 10086
Gunner's Mate 3, NavPers 10181
Gunner's Mate 2, NavPers 10184
Gunnery Drill Guide, NavPers 10885
**Naval Ordnance & Gunnery*, Vol. 1, NavPers 10797-A
**Naval Ordnanee & Gunnery*, Vol. 2, NavPers 10798-A
Basic Hand Tool Skills, NavPers 10085

There are, of course, other BuPers publications that you will find useful from time to time—the training courses for

Fire Control Technicians, Torpedoman's Mates, and Minemen, for example. Other BuPers manuals (for example, *Education and Training*, NavPers 10827–A), will be of value in connection with your military duties. But the above will serve as a basic list of those useful in your work as a technical specialist.

One other useful BuPers publication to know is the quarterly *Naval Training Bulletin*, which, though it covers the area of training generally, both ashore and afloat, often has articles that are of particular interest to you as a petty officer in the gunnery department. You can procure it from your ship's education officer.

For information on supply, your main source of information is the Bureau of Supplies and Accounts' big *BuSandA Manual*. Since this publication is constantly undergoing revision to keep it up to date with the ever-changing supply problem, it is published in loose-leaf form. For further discussion of the Navy's supply system and the publications about it, see the chapter on supply elsewhere in this course.

Certain equipment that is procured by the Bureau of Ships is the Gunner's Mate's responsibility when it comes to maintenance, repair, and other upkeep. Examples of such equipment are dredger hoists, high-pressure air systems, and magazine sprinkler systems; and there are many others. For this reason, you will find it necessary to use BuShips publications. The most important single one is the *BuShips Manual*, a large loose-leaf compilation divided into a number of chapters, each of them devoted to a given topic or type of equipment. New or revised chapters are usually issued as individual units, to be put into the binder that holds the manual together.

The *BuShips Manual* is good for general information on equipment associated with ordnance installations; but for details on installation, maintenance, and disassembly you will have to go to the technical instruction books prepared by the manufacturers of the equipment. These are furnished to the ship at the time the equipment is installed by the shipyard, and are kept on file either by the engineering officer or in the log room. BuShips issues changes to these publications as required.

Fleet Publications

Finally, let us briefly take up the publications issued by or through the Navy's forces afloat. Most of these have to do with tactics, organization, and other matters; but some are important for all personnel connected with ordnance.

The series of publications known as USF's (U. S. Fleet publications) contains tactical information, instructions as to conditions of readiness, attack and defense doctrines, sample exercises, general instructions on the conduct of practices, and other information and orders directly affecting the gunnery department. It is one of the important duties of the gunnery officer to see that the information in applicable USF's is constantly available to enlisted personnel charged with maintenance and upkeep of the ordnance equipment aboard his ship.

At this writing the doctrinal USF series is in the process of being superseded by Naval Warfare Publications (NWP series). The NWP's when made effective will be the source books for the warfare doctrine of the U. S. Navy, and will contain all of the information presently contained in the USF's, corrected and brought up to date, and will also cover the recent developments of naval warfare evolved since the conclusion of World War II.

Issued in conjunction with the NWP series are the NWIP's (Naval Warfare Information Publications) and the FXP's (Fleet Exercise Publications). The FXP's contain exercises necessary for the promotion of proficiency in the procedures set forth in the NWP series, and the NWIP's supply the detailed technical instructions not found in the NWP's.

As a Chief Gunner's Mate or Gunner's Mate First Class it is up to you not only to study the NWP's and other fleet publications that you are expected to know in order to do your job effectively, but to pass them on to the men below you as required.

The Gunnery Department Library

In the articles above we have reviewed the publications that you are likely to deal with in your specialist job as leading Gunner's Mate. Those on supply and on engineering equipment will be on file respectively in the supply office and in the engineering office or log room. USF's, NWP's, and ATP's, may be on file either with the communications officer or with the gunnery officer, depending on security classification and the ship's standing policy. All the others discussed in the preceding articles of this chapter, however, are kept in the gunnery department as its publications library.

The gunnery department library must be accessible (within the limits imposed by security considerations, of course) to all officers and men concerned with ordnance equipment operation and maintenance, so that they can keep abreast of current information on the subject. But, at the same time, publications on ordnance gear cannot be allowed to become scattered indiscriminately all over the ship, nor can they ever be considered the private property of any individual, regardless of his duties in the gunnery department. Probably the best solution is to arrange some sort of charge-out system, so that the pamphlets and books in the ordnance technical library can be made available to the men who need them. At the same time, an efficient system will ensure that any publication not actually on the library's shelves can be traced without delay to the individual who actually has it. To keep the system effective, the gunnery officer should appoint some individual as "librarian" to keep track of the library's contents. On larger ships, the Yeoman assigned to the gunnery department should have this duty.

On ships where a Yeoman's services are available to the gunnery department only on a part-time basis, a striker may be assigned to assist with this chore.

The gunnery department's librarian should keep the publications in the library neatly shelved or filed in numerical order so that they can be located without delay, and should maintain the charge-out system so that any publication not actually on the shelf or in the file can be instantly traced to the individual who has it. There are several measures which will help to ensure this. For example, each borrower should be required to sign a custody card or chit, and should return the publication directly to the library when he is finished with it; if he merely transfers it to some one else, the publication is likely to get lost. It may be helpful also to set a time limit for borrowing any publication—say, three days.

CONFIDENTIAL publications must be kept in a safe in accordance with security regulations when not in use. If the gunnery department office is equipped with a safe, they may be filed there; otherwise, they should be kept by the communications officer. The communications officer will, of course, maintain custody of all ordnance publications classified higher than CONFIDENTIAL.

Ordinarily, the gunnery department Yeoman will be responsible for logging in new publications, entering and filing changes, submitting requisitions for publications, and the like. He may have the assistance of the librarian if one is assigned.

As leading Gunner's Mate, it most likely will be up to you to see that all this is done according to Hoyle. In fact. the gunnery officer is likely to expect you to take care of this detail work without further reference to him, and so you can be your own Hoyle and work out your own system.

It's also a good idea for you to keep a weather eye out for new publications and the obsoletion of old; you can do this by checking new editions of OP 0 as they arrive to see what new ordnance publications it lists, by checking new OCL's, OML's, OP changes and the like, by checking the lists of new publications in the *Bulletin of Ordnance Information* and the *U. S. Naval Training Bulletin*, and by remembering that new OrdAlts and NavAlts may affect information in other ordnance publications long before those other publications are actually revised. In this way you can keep the Yeoman on his toes and ensure that your publications are up to the minute.

Publication Distribution

Although the actual making up of requisitions is the Yeoman's function, it is worth while to devote a paragraph or two to the distribution system through which ordnance publications reach your ship.

To a large extent, the publications distribution system is automatic. It is set into motion months before the ship is even commissioned, when the commissioning allowance is sent without request directly to the ship's prospective commanding officer (in care of the naval shipyard or commissioning detail concerned) by the Naval Gun Factory. The commissioning allowance includes all publications required for the ordnance equipment which the ship's Allowance List calls for. Thereafter, new publications (including revisions and changes) are automatically distributed to all naval activities to which specific ordnance equipment is assigned; to those which may be called upon to stow, transport, overhaul, repair, or otherwise handle such equipment; to those that train personnel in operation, maintenance, repair, or handling of such equipment; and to higher echelons to which any of the above-mentioned are directly responsible. Thus, if the DD to which you are assigned is armed with 5″/38 twin mounts, its gunnery department will automatically receive the OP's, OML's, etc. pertaining to such armament—as well as the other publications pertaining to the other armament aboard, and those publications that apply to DD gunnery operations generally. It is true that some naval activities (like naval shipyards) receive copies of ALL ordnance publications, but ships receive only those that they will actually use for the equipment specified on their Allowance Lists.

Of course, though this automatic system takes care of the bulk of your ship's requirements regarding ordnance publications, your gunnery department may require additional copies (for example, if those aboard are lost through enemy action) or it may be necessary to have copies of publications relating to items not on the ship's Allowance List. Or the publications due the ship may be lost or misrouted. Under such circumstances, your Yeoman will requisition them using the standard NavExos form. It will be up to you to help him in keeping a close check on the ordnance publications your ship should have. This will be especially important if you are a member of the ship's precommissioning detail.

For current complete information on requisitioning and distribution of ordnance publications, see the introduction to OP 0.

CONCLUSION

In this chapter you have studied the Navy's system of ordnance publications. You have been using the publications in this system ever since you were a GM striker, but it helps to know the system as a whole, and you are responsible for knowing it as a leading Gunner's Mate. This chapter has also discussed your responsibilities with respect to sources of ordnance information aboard ship. True, these are not your primary responsibilities in the sense that, say, maintenance of weapons is; but attention to these details will help you make a success of the larger aspects of your job as leading Gunner's Mate.

QUIZ INSTRUCTIONS

As in other Navy training courses, the quizzes at the end of each chapter of this course are intended for you to use as a review of the material in the chapter and as a way of finding out how well you have learned it. A good way to use the quiz is to answer the questions on a separate sheet of paper after you have studied the chapter and feel that you have mastered what's in it. Then check your answers with those in the back of the book. If you have missed any, then you had better go over the entire chapter, with a particularly intensive review of the points you failed to get the first time. In general, the quiz questions cover only a few of the high points in the chapter; they do not cover the chapter content intensively. Answering all the quiz questions gives you a spot check of how well you have covered the chapter content.

That's why, if you miss any, you should review the ENTIRE chapter, and not confine yourself to the specific point you have missed.

These books are Navy property, and they must not be marked up or defaced in any way. Therefore you must make no interlinear notes or marks, nor should you indicate the quiz answers by writing in the book. Such marks or notes will spoil the book for the next man who gets it. So write your answers on a SEPARATE sheet of paper. Remember that nobody will rate you on how well you answer the quiz; it is intended only as a convenience for you.

QUIZ

In each of the following, select the best answer.

1. The index for OD's is
   a. NavOrd Info 0 c. OP 0
   b. OD 0 d. RPS 6
2. The abbreviation OS refers to
   a. Ordnance Standards
   b. Ordnance Charts
   c. Ordnance Specifications
   d. Ordnance Line Sketches
3. Which of the following publications are NOT indexed in OP 0?
   a. OHI's
   b. OML's
   c. Army publications relating to ordnance
   d. Registered ordnance publications
4. Registered Ordnance Pamphlets are designated
   a. ORD c. NavOrd Info
   b. OP d. RPS
5. Which of the following kinds of information about ordnance equipment will you NOT ordinarily find in an OP?
   a. Theory of operation
   b. Methods of design
   c. Overhaul and repair
   d. Safety precautions
6. When they are registered, BuOrd publications are
   a. assigned serial numbers
   b. classified Secret or Top Secret
   c. made subject to the standard regulations regarding security
   d. charged as the property of the recipient

7. The principal purpose of OML's is to
    - a. serve as primary source of technical information on all ordnance gear
    - b. serve as a means of issuing technical ordnance information rapidly to the Fleet
    - c. serve as a means of issuing policy information regarding ordnance matters rapidly to the Fleet
    - d. make changes or amendments to the *BuOrd Manual*

8. OML's are replacing which of the following publications?
    - a. OCL's
    - b. OrdAlts
    - c. OHI-V's
    - d. OMI-V's

9. Which of the following is ordinarily a tag or card attached to the equipment to which it refers?
    - a. OML
    - b. OCL
    - c. OHI
    - d. OD

10. Which of the following statements is most applicable to OrdAlts?
    - a. They describe maintenance procedures for the ordnance gear they refer to.
    - b. They constitute a basis for requisitioning the materials required for the alteration.
    - c. They are classified as Urgent, Routine, or Unclassified, depending on the extent to which they alter the military characteristics of the ship.
    - d. They are indexed in OP 0, which also indicates their current status.

11. The *Bureau of Ordnance Manual* is amended only by
    - a. OCL's
    - b. NavAlts
    - c. *Navy Regulations*
    - d. changes

12. OCL's are amended only by
    - a. OCL's
    - b. NavAlts
    - c. AlNavs
    - d. changes

13. Which of the following are NOT issued in the form of OD's?
    - a. Allowance lists
    - b. Equipment lists
    - c. Installation and alignment data
    - d. Tables of weights and dimensions

14. Which of the following Army publications is part of the Army ordnance supply catalog?
    - a. TM's
    - b. TB's
    - c. SNL's
    - d. SR's

15. Which of the following publications would you ordinarily draw from the communications officer aboard your ship?
    - a. USF's
    - b. *BuShips Manual*
    - c. Navy Training Courses
    - d. TO's

CHAPTER 2

MAINTENANCE, REPAIRS, AND ALTERATIONS

INTRODUCTION

In your previous experience with naval ordnance equipment (including ammunition), both as Seaman and as Gunner's Mate, and in the other naval training courses that you have studied, you have learned a great deal about how that equipment works, how it is constructed, and, especially, about how to keep it in good shape and how to repair it when it breaks down. To earn promotion to GM1 or GMC, you are expected to demonstrate increased knowledge of ordnance equipment and proficiency in its maintenance—proficiency that you can attain only by constant study of the gear and the publications about it, and by constant working on and practice with the equipment itself.

This chapter is intended to do two things. One is to present a review of your main responsibilities with respect to naval ordnance maintenance, plus a sort of bird's-eye view of the whole system of naval ordnance maintenance as it affects your duties as a Gunner's Mate First Class or Chief. The other objective of this chapter is to take up in rather more detail several aspects of naval ordnance maintenance that you have probably not had much to do with up to now.

Your Maintenance Responsibilities

As a leading Gunner's Mate, much of your time will be taken up with maintenance and repair. Most of your work will be supervision, but frequently you will have to take a hand yourself, too. You are responsible for the assignment and careful supervision of Gunner's Mates assigned to routine maintenance and repairs of the various guns, mounts, and ordnance equipment. You are also responsible for repairs to guns and hoist mechanisms.

Suppose that you are assigned as a Chief Gunner's Mate, "in charge of gunnery maintenance." Your duties are to organize, supervise, and perform maintenance and repair of all guns aboard ship. This means that you supervise Gunner's Mates and strikers in routine cleaning, maintenance, and repair of main-battery and automatic weapons.

Efficient and orderly routine work calls for a working schedule, and you will confer with the gunnery officer in order to divide your time between the maintenance program and the operating schedule. After that, your job will be largely to assign your men, to supervise them, and to inspect their work.

You will assign your men to cleaning and repair stations, taking account (so far as you can) of their abilities and talents. Get to know your men as well as you can, their backgrounds, their education, their mechanical abilities; and you will find that you can assign them more intelligently. Make frequent inspections of their work, once you have assigned them and given them a job, and tell them specifically how to do the job when necessary.

It will be your special job to examine and diagnose equipment failures, and you will probably take a hand in more complicated repairs to such mechanisms as hydraulic systems of guns and hoists. In such jobs, you will be assisted by the lower rates. You will make or supervise daily inspections of 5"/38 mounts, checking the recoil and counterrecoil systems and other vital mechanisms, and directing replenishment of hydraulic fluid and air pressure when necessary.

These jobs call for certain specialized knowledge. As the leading Gunner's Mate in charge of maintenance, you must know:

1. Construction, operation, maintenance, and methods of disassembly, repair, and reassembly of all types of armament

on the ship, from small arms to the largest guns; and of hydraulic power equipment of mounts—in order to diagnose casualties of the gear, and to make repairs.

2. Blueprint and schematic drawing interpretation—so that you can detect and localize failures without having to tear down the equipment any more than necessary.

You must not only be able to read and interpret blueprints and schematic drawings, but you must also be able to make working sketches for repairs.

These working sketches are not blueprints, of course, and need not be as accurate as blueprints are.. But you must make the job clear to your men by using the draftsman's language—lines. (It is your job to know this language and how to use it. If you are rusty, get out the basic training course *Blueprint Reading and Sketching*, NavPers 10077–A, and give it some study.)

As a GM1, your responsibilities will ordinarily not be so broad as those of a GMC, but you will be responsible for supervising a large portion of the gun and mount maintenance. For example, suppose you are a GM1 "in charge of 5"/38 maintenance." In that position, your job is to supervise and assist Gunner's Mates of lower rates in routine cleaning, maintenance, and repair of 5"/38 guns, hoists, and handling room equipment. You and your men check the recoil and counterrecoil systems, replenishing hydraulic fluid and boosting the air pressure when necessary. You clean and lubricate the guns after each firing and periodically when required, following the check-off list. You diagnose equipment failures, and make repairs if possible. You assist the Gunner's Mate-in-charge in making repairs to more complicated equipment, such as hoist hydraulic systems or training and elevating mechanisms.

UPKEEP

So far we have been using the term "maintenance" in a broad, general sense, to include lubricating, servicing, inspecting, repairing, adjusting, and exercising your equipment—in short, doing whatever is necessary to keep it in tip-top shape.

In earlier courses in this series, we have recognized several phases of maintenance—preventive, routine, and emergency—but now it is time for us to consider in more detail the aspects of maintenance with which you as a leading Gunner's Mate will be particularly concerned.

For our purposes in this chapter we can think of this whole business of maintenance as consisting of three major segments—upkeep, repairs, and alterations. Earlier courses in this series have mostly discussed upkeep—lubricating your equipment, inspecting, adjusting, and exercising it, protecting it from corrosion, and the like. You can think of upkeep as including all the routine operations that are prescribed on check-off lists. By the time you've become a candidate for GM1 or GMC, you should be pretty well up on the technical details of ordnance equipment upkeep; if you're not, you should study the earlier courses in this series and the OP's and OCL's on the equipment you have to brush up on.

NOTE: Though the term MAINTENANCE is used in this course in a general sense to include overhaul, repair, and alteration, as well as upkeep, you will find that many official publications use the word to apply to upkeep only. In general, this distinction is not likely to give you much trouble; the context will ordinarily show clearly which meaning applies.

With respect to upkeep, your chief responsibility as a GM1 or GMC is to see that it is done right—in short, supervision. This means two things: You will have to see that your men are trained right from the start to do a good job of upkeep, and you will have to inspect their work. Remember that from the gunnery officer's point of view this is YOUR responsibility rather than that of the individual men under you.

The natural guide to use for material inspection is the check-off list, which should also be used by the men doing the actual upkeep work. It is usually most convenient to follow the same sequence of steps as in the check-off list when inspecting the material. But you cannot keep an adequate check on how well the work is being done merely by inspecting it afterward. Many items on the list—for instance, exercising the equipment—cannot be verified by inspection afterward. You must make it your business to be around while the work is going on—not to carp and criticize each man in the presence of his mates, but to be available to answer questions, to lend a hand where necessary, to note working methods of each individual, to point out omissions, and at least to indicate by your presence that you are not sparing any efforts yourself.

Maintenance of Mounts 5″ and Smaller

Since maintenance of dual purpose and AA gun mounts has been taken up in considerable detail in earlier courses in this series, your best source of information is a review of those earlier courses along with the OP's and other publications on those weapons. The regular check-off lists will provide a convenient general guide to upkeep operations. In the absence of others, you can use the typical 5″ battery check-off list published in the Navy training course for GM3 (volume 3, NavPers 10181).

Maintenance of Major Caliber Equipment

In general, maintenance of larger units—turrets—is different from that of smaller weapons more in degree than in kind. However, there are certain maintenance operations that are peculiar to turrets—or at least are much more important in main-battery equipment than in AA and dual-purpose weapons.

Note that as compared to smaller weapons, there are relatively few turrets in our fleet, and the differences between installations are great enough so that accurate general statements are especially difficult to make. You will therefore find it necessary to study the appropriate OP's and other technical publications on the specific main-battery installation you are stationed on to get the working details of your maintenance job on a cruiser or battleship. The material following is intended to serve only as an introductory guide to turret maintenance. (If you want to refresh your memory on the main outlines of both bag-gun and case-gun turret construction and operation, see the earlier courses in this series, especially GM3.)

BORE AND CHAMBER MAINTENANCE. As in smaller equipment, the bore is kept oiled when no firing is to occur; the main difference in the way this is done is that the bristle sponge is usually hauled through the bore with a line, rather than with a sectional handle.

Gaging (with bore gage), after-firing care, and decoppering are done in much the same way as on 5″ mounts. However, since most turret guns have LINERS, the liners must be periodically checked for TWIST and EXTENSION.

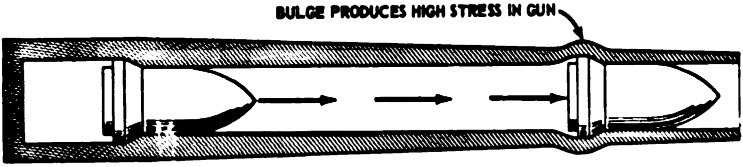


Figure 2–1.—Exaggerated sketch showing how the projectile causes high stresses in the barrel.

As the projectile is forced up the bore by propellent gas pressure, the gun's rifling cuts into the rotating band and twists the projectile sharply so that by the time it passes the muzzle it is rotating at high speed. This is nothing new to you, of course. But, as Newton's third law of motion states, every action results in an equal and opposite reaction. As the rifling cuts and squeezes the rotating band, so does the rotating band erode and push outward on the rifling. And as the helical grooves and lands of the rifling twist the projectile as it moves through the bore, so does the inertia of the projectile tend to twist the liner in the opposite direction.

One result of the conflict of these opposing forces is shown exaggeratedly but graphically in figure 2–1. It is this tendency of the projectile to enlarge the bore that, in lined guns, causes the liner, squeezed between the projectile and gun tube, to protrude from the muzzle and breech ends of the barrel.

Most lined guns have a locking ring that prevents serious extension of the liner to the rear, because, especially in guns with interrupted-screw breech mechanisms, liner protrusion to the rear will interfere with the closing of the breech plug. Liner extension usually takes place at the muzzle.

The *BuOrd Manual* at present provides that after each target practice or series of firings, the following data on tube and liner movement must be measured and recorded:

a. Distance from breech face of gun to rear face of liner.
b. Distance from breech face of gun to rear face of tube.
c. Protrusion of liner beyond the tube at the muzzle.
d. Amount of rotation of the muzzle end of the rifled member relative to the next outer member.

Item d above refers to liner TWIST. When a new gun is installed in a turret, or when a new liner is installed in a gun, the liner and tube should be marked by a continuous scribe mark. As the liner twist increases, the mark on the liner will be displaced from that on the tube, and the amount of twist can be measured by determining the distance between the two marks.

The following treatment of liner extension is authorized:

a. When protrusion of the liner at the muzzle exceeds one-half inch, the protruding part must be cut off flush with the muzzle.
b. When protrusion of the liner at the breech interferes with breech mechanism operation, the liner must be faced off as necessary to restore the drawing dimension for the distance from breech face of gun to rear face of liner, and the gas-check seat must be reamed to restore its drawing dimension relative to the breech face.

As sometimes happens, the liner at the gun breech may move FORWARD. This is of no consequence, up to a point, but, if excessive, gas may leak past the gas-check seat. Serious leakage will require replacement of the gun.

Liner elongation may cause STEEL CONSTRICTION. On guns without liners, steel constriction (as compared with COPPER CONSTRICTION, caused by excessive copper deposits) is rare; it is usually caused by some serious damage, as from enemy action, to the exterior of the gun tube. In older lined guns, the liners had shoulders that normally were adjacent to shoulders on the interior of the tube. When the liner lengthened, its shoulders tended to foul those of the tube, and this caused constriction. The best way to deal with this on shipboard is to use the authorized lapping head. Present liners have been redesigned to eliminate these shoulders and this cause of bore constriction.

It is possible for the ship's force to saw off liner protrusions at the muzzle, but it is not easy. As for liner protrusion at the breech, or for dealing with other effects of liner distortion, it will be necessary to await the ship's next visit to a naval shipyard. It will be up to the gunnery officer to decide whether guns afflicted with these liner troubles may be fired.

The *Bureau of Ordnance Manual* provides that when metal is removed from either the muzzle or breech face of the liner, a special report must be submitted to the Bureau (with a copy to the Naval Gun Factory), including the following information:

1. The serial number, ship's number, mark, and mod of the gun.
2. The amount of metal removed.
3. A complete history of liner movement since the gun was installed (or since the last previous report on the subject for that gun), with number and kind of rounds fired, and liner movement occurring at each target practice or series of firings. This information is available in the turret's logbooks.

STARGAGING AND BORE SEARCHING. As you know, each round fired from a gun causes the bore to erode or wear. The erosion of the bore caused by one round isn't much, but multiplied by several hundred, such erosion begins to affect the gun's performance by reducing muzzle velocity. Reduced muzzle velocity, in turn, results in increased dispersion, and decreased range at a given elevation. The Naval Proving Ground prepares graphs and charts from which velocity loss of a gun in feet per second can be determined, provided the amount of barrel erosion is known in terms of bore enlargement at the origin of rifling. You find the value of this enlargement by measuring the bore and subtracting from this figure the original size of the bore. The difference represents enlargement due to erosion.

Up to a certain point, this loss in muzzle or initial velocity (I.V.) can be compensated for by elevating the gun a little more. (That is why I.V. is an input into the fire control computer.) But when the wear gets excessive, loss in range and increase in dispersion make it necessary for the guns to be relined or replaced.

The ideal way of keeping track of I.V. loss so that the fire control system could be continuously corrected for it would be to measure the I.V. for each round fired, and then to average the I.V.'s for groups of shots in order to obtain a value that would be reliable and accurate enough to crank into the computer. Until recently, however, this has not been a practical thing to do as a routine aboard combat ships. In the past, accurate determination of I.V. has been a proving-ground operation requiring the use of an instrument called the CHRONOGRAPH. Prewar and early wartime versions of this instrument used either wire screens or magnetic coils (depending on the exact type of chronograph used) set up in consecutive pairs, through which the gun being tested would fire; projectile velocity was measured by electrical methods of clocking very accurately the passage of the projectile through the screens or coils.

Chronograph instruments of this type are quite accurate, but they are at best laboratory instruments, and it would be impractical to use them to keep routine track of I.V. aboard a combat ship. With the advent of radar, however, it was possible to attack the problem with new techniques which would allow routine shipboard measurement of I.V. There is also under development at this writing another method (not using radar) which measures projectile velocity while the projectile is still in the bore.

So, in the foreseeable future, Navy combat ships will be able to make accurate routine I.V. measurements while firing. At the moment, however, most ships do not have this equipment, and measurement of erosion is an important way to estimate I.V. loss. Moreover, serious bore wear causes fuze malfunctioning and possible gun failure. So it will probably be necessary to continue measuring gun erosion as long as we use guns.

Gun erosion can be figured in one of two ways—by keeping a careful record of the number of rounds fired, and by gaging.

The rounds-fired method is the basic method for determining gun erosion. But this method offers some difficulties. A hundred rounds fired continuously in rapid fire, for example, will cause considerably more erosion than a hundred rounds fired over a longer period of time. Conversely, if a bag gun is fired using less than a full propelling charge, the projectile will have a lower initial velocity and cause less erosion.

These considerations would make any simple count of rounds fired much too inaccurate to be useful in determining erosion. To get around this difficulty, there was developed the concept of the EQUIVALENT SERVICE ROUND (E.S.R.). Each projectile-velocity combination for a given gun is assigned an E.S.R. value, based on data developed in Naval Proving Ground tests. Thus, a service round consisting of an AP projectile fired with full powder charge is assigned an E.S.R. of 1. Lesser powder charges, other types of projectiles, or combinations of these, have smaller E.S.R. values, down to a value of 0.03 E.S.R. (This value means that you would have to fire 33 such rounds to develop the same erosion as that produced by one full service round with AP projectile.) So, in counting rounds for erosion-calculation purposes, it is necessary to count each round fired only in terms of its E.S.R. value, as published in tables compiled by the Naval Proving Ground.

Even with this refinement, the rounds-fired count is at best an approximation of the actual state of the gun bore with respect to erosion. So, in order to check the enlargement of the bore, the gun must be gaged at periodic intervals. That is, the actual diameter of the bore is measured at the points of most wear. In machine guns and small arms, this area is the forcing cone.

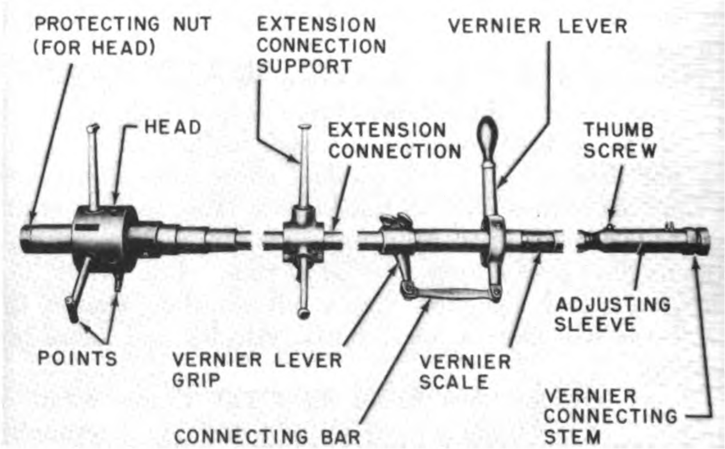


Figure 2-2.—Stargage.

Because large-caliber guns suffer from erosion proportionately more, per rounds fired, than machine guns or small-arms weapons, it is not enough, in measuring their bore wear, to gage only headspace or forcing cone advancement, as you do in smaller weapons. The instrument used for measuring erosion for larger guns is the STARGAGE, so called because of the star-like pattern of the instrument's three feelers or points that actually measure the gun bore.

Stargages are not generally issued to combat ships, since stargaging is usually done alongside repair ships by special stargaging parties or at a naval shipyard. (All stargaging should be done by the forces afloat as much as possible.) The work will be supervised by some one from the tender or yard, but as a Gunner's Mate you should be familiar with the stargage and the procedure in obtaining the readings.

The stargage shown in figure 2–2 consists of a head, mounted on a long tube, with metal points 120° apart extending radially from it. These three points form a Y and press against the bore of the gun. Points of suitable length are provided for each caliber of gun to be measured. The bases of these points are spring loaded to bear against a tapered expanding plunger; as the plunger moves lengthwise, the points are cammed outward or inward.

Figure 2–3 shows a schematic diagram of the stargage.

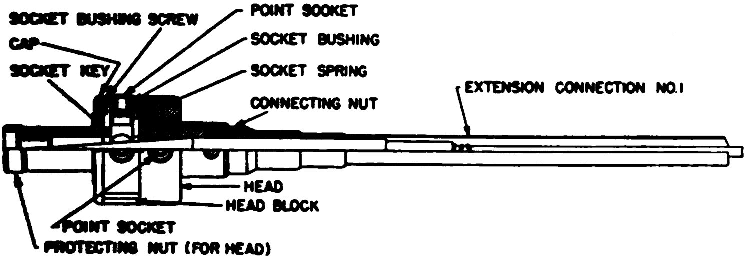


Figure 2–3.—Schematic diagram of the stargage.

The expanding plunger is fastened to an extension rod which moves inside an extension tube attached to the head. These extension rods and tubes are approximately 50 inches in length. Several sections are furnished so as to adapt the gage to any length gun. A vernier lever and vernier are attached to the last section. Movement of the vernier lever causes the plunger to move longitudinally, camming the points inward or outward.

The vernier, provided to measure the amount of movement of the contact points from zero, has a fixed scale and a movable scale calibrated in thousandths and ten-thousandths of an inch. It is read in the same manner as any other vernier scale. (Fig. 2–4.)

Let's review briefly the process of reading the vernier.

Each scale has a central zero graduation. To read the vernier, count on the fixed scale the number of graduations the zero on the movable scale has moved to the right or left from zero on the fixed scale. Neglect any partial graduation. Call each graduation ten one-thousandths (0.010) of an inch. Then add to this as many one-thousandths as there are spaces on the moving scale between the zero and that graduation which lines up exactly with a graduation on the fixed scale.

Thus in figure 2–4, there are three full spaces on the fixed scale between the fixed zero and the movable zero. This represents thirty one-thousandths (0.030) of an inch. As you count along the moving scale, you find that the eighth graduation coincides exactly with one of the graduations on the fixed scale. This represents eight one-thousandths (0.008) of an inch. Add this to the other reading. The final reading is, then, 0.038 inch.

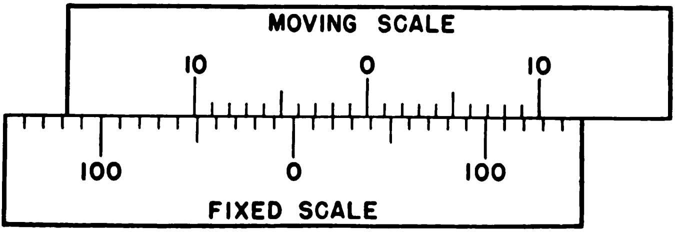


Figure 2–4.—Reading the vernier scale.

Since the purpose of the vernier arrangement is to measure the enlargement of the gun bore, it must first be set on zero (which corresponds to the exact bore diameter of a new gun). This is done by firmly but gently setting the stargage contact points against the inner surface of the TESTING RING for the caliber of gun you are measuring, and then zeroing the vernier. To do this, turn the adjusting sleeve (see fig. 2–2) so that the zero marks on the movable and fixed vernier scales coincide, then lock the sleeve in place by the thumb screw. Last of all, remove the gage points from the ring.

A testing ring is provided for each caliber of gun to be stargaged.

To gage the gun, carefully insert the zeroed instrument into the bore with the points in an inverted Y, to the first place to

E.O.
Rev.3a

Tube

	5" From Muzzle		12" From Muzzle			At Muzzle	
	E-2		F-1	F-2			
Serial No.		Mean			Mean	Unsymmetrical Wear	Muzzle Time
1	19	20	21	22	23	24	25
51 816	.012	.012	.011	.009	.010		
52 826	.012	.012	.014	.013	.0135		
53 641	.008	.008	.005	.005	.005		
54 828	.005	.0045	.005	.004	.0045		

To be

Original
1 Copy

C.J. Comer

C.J. COMER CHGN. USN.
Reporting Officer.

be measured. Then move the vernier handle until all the contact points touch the gun. Next, take readings from the vernier scale. Be careful not to apply any more force on the vernier handle than was applied when setting the points in the testing ring. It is easy to spring the points and obtain a false reading.

Two stargage readings are always taken at each point of the bore that is measured. The second reading is taken by revolving the gage until the points are in an UPRIGHT Y position. Whenever the instrument is taken from the gun, the contact points should be inserted in the testing ring to verify that the vernier is still on its zero position.

From stargage data, when compared with the Erosion Range Scales (E.R.S.) put out by the Naval Proving Ground, it is possible to compute the loss of muzzle velocity and the decrease in range of the gun.

Routine stargaging is done regularly at the intervals prescribed by the *BuOrd Manual* (which at present requires them annually); special stargaging may also be performed as required. The result of stargaging measurements are reported to BuOrd on NavOrd Form 54, shown in figure 2–5.

Present regulations require seven pairs of readings to be recorded on NavOrd Form 54 for each gun stargaged, as follows:

1. Two readings (A–1 and A–2 on Form 54) at the origin of the bore.
2. Two (B–1 and B–2) one inch forward of the origin of the bore.
3. Two (C–1 and C–2) twelve inches forward of the origin of the bore.
4. Two (D–1 and D–2) at the muzzle.
5. Two (E–1 and E–2) one inch in from the muzzle.
6. Two (F–1 and F–2) twelve inches in from the muzzle.
7. One (recorded in columns 24 and 25 of the form) at the muzzle.

All of these are stargage measurements except for the last one.

The first of each pair of readings is made with the stargage points in an inverted Y and the second in an upright Y. The two readings of each pair are averaged to give the mean reading at each place measured.

Point "A" mentioned in the form is the origin of the bore (or the forward end of the forcing cone). This is, as you remember, a crucial point of wear, and it is extremely important to locate it accurately when making stargage measurements. Tables for locating point "A" in different calibers of guns are published in OD 2780.

The measurement at the muzzle (the last one listed) is made not with the stargage but with a MUZZLE DISC inserted into the muzzle. Then feelers are used to detect possible clearance between the tops of lands and the disc. If no measurable clearance is found, then NONE is entered in column 24 on Form 54. If there are measurable clearances, measure and record the maximum clearance in column 24, using feeler gages, and record its position in "muzzle time" in column 25. (Muzzle time likens the muzzle, as you face it, to the face of an ordinary clock—not the 24-hour variety—to denote location, so that, for example, the bottom edge is 6 o'clock by muzzle time, the top edge is 12 o'clock, and so on.)

As a GM1 or GMC in charge of gunnery maintenance aboard a combat ship, you will not usually be required to perform the stargaging operations described above while your ship is being serviced by a repair ship tender. However, you may be assigned to accompany the stargaging party to witness the gaging operation and compare readings with those of previous gagings. You should therefore know how gaging is done, and you should be able to help verify unusual or abnormal readings before the stargaging party leaves the ship.

As a GM1 or GMC in the ordnance shop aboard a repair ship or tender, on the other hand, it will be up to you to conduct the entire operation. And it is possible that you may be required to perform this work even if you are on a combat ship, if the ship is at a Navy yard and stargaging gear is issued to you for that purpose.

Bore searching is done by means of an instrument called the BORESCOPE OF BOROSCOPE. Fundamentally, this device, which exists in several variant forms, consists of a mirror which is passed down the bore of the gun being examined so that the rifling is reflected in it, optical elements for viewing the image, and provisions for illuminating the bore interior. Bore searching equipment is available at fleet overhaul yards and aboard some tenders. It is not required as a matter of routine inspection for guns in service; it is employed where guns have suffered torn rifling or other serious internal injury.

YOKE. On bag-type guns, the yoke functions not only as a counterweight (otherwise, the placement of the trunnions near the breech would make the gun muzzle-heavy) but as a securing point for recoil brake and counterrecoil mechanism piston rods. This puts the yoke under heavy strain during every recoil-counterrecoil cycle and causes the yoke to tend to move longitudinally with respect to the gun barrel. The yokes on 8-inch, 14-inch, and 16-inch guns are anchored in place by locking rings intended to force the yoke firmly against the shoulder or band on the gun, so as to prevent such movement. However, because of the tendency of the ring to back out, the proper position of the ring should be periodically verified by measurement, and the ring should be tightened if there is provision for it. Displacement of the ring will cause the breech mechanism to jam.

BREECH MECHANISM MAINTENANCE. Because the Welin interrupted-screw type breech mechanism of a bag gun is completely different both in construction and operation from the sliding-wedge type breech mechanism of a case gun, the maintenance operations are different, too. Let us go into them in some detail. Below are listed some of the principal items that maintenance personnel must look to in the upkeep of bag-type turret guns. Figure 2–6 shows a typical (16″) bag-type mechanism.

1. GENERAL CARE IN HANDLING. All components of the breech mechanism, and particularly the meeting surfaces of gears, racks, engaging screw threads of plug and screw-box liner, pistons, and the like, must be continually inspected for burs and galling, must be kept free of all abrasive materials like emery, and must be properly lubricated. (More on this below.) The breech plug must be in alignment with the

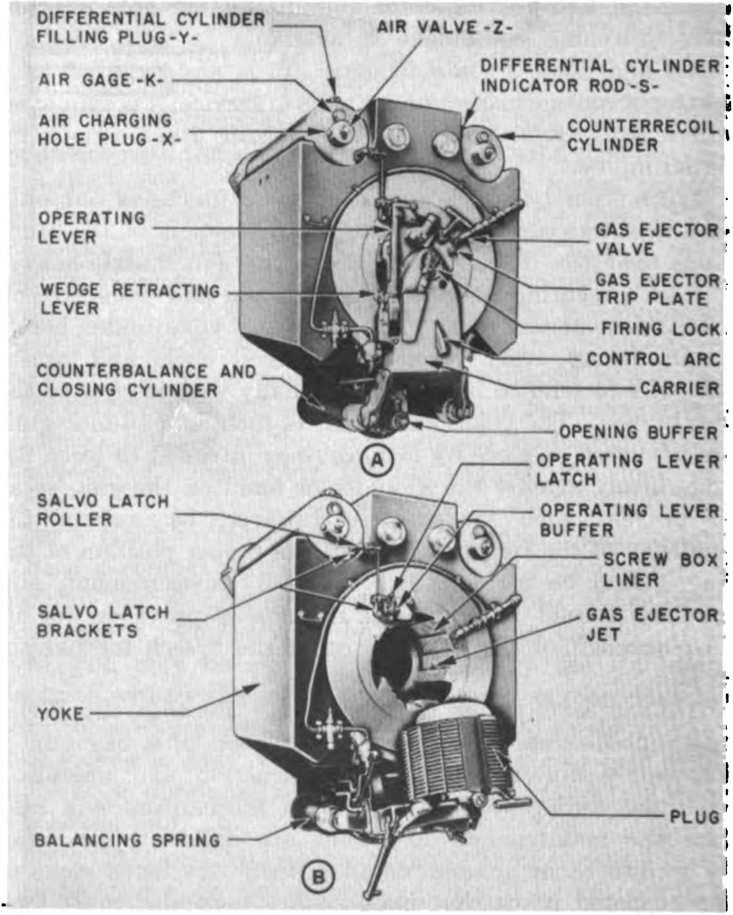


Figure 2-6.—16" breech mechanism, Mk 4 type. A: Breech closed. B: Breech open.

screw-box liner, and the mushroom and gas-check pad assembly must be aligned with the gas-check seat, when the breech is being closed. Misalignment may cause interferences, excessive galling, distortion of parts, and other damage. Force, therefore, must NEVER be used in closing breech mechanisms. If it is in proper working order, no bag-type breech mechanism will ever require force for proper manual operation.

2. LUBRICATION. In addition to the general requirements of proper lubrication that you should already be familiar with, there is a special caution you should know about in connection with bag-type breech mechanisms. Overlubrication is extremely dangerous when the gun is fired. Excessive lubrication allows the breech plug to unscrew slightly during firing, causing strain and distortion of operating parts. Here is a recommended procedure for lubrication of the engaging threads of interrupted-screw type breech mechanisms:

a. Remove all lubricant from interrupted threads of plug and screw-box liner by wiping and by use of a solvent, until all threads are dry.

b. Apply the proper lubricant, SPARINGLY, to the threads of the PLUG only. (For the proper lubricant, see the appropriate lube chart.) "Sparingly" means that after lubrication there will be just enough to give your finger tip a SLIGHTLY oily appearance when you rub it along the thread surface. Remember, do NOT apply lubricant directly to the screw-box liner threads.

c. Close the breech, and work the plug sufficiently with the operating handle to lubricate the screw-box liner threads. That's how they get their lubricant.

The above applies to preparation for firing only, and should be repeated every day that the gun is to be kept in firing condition. However, to reduce wear, additional lubrication is necessary when the breech mechanism is used for drill purposes, and under conditions where the gun will not be required to fire on short notice.

Note also, below, the importance of proper lubrication of the plug bearing and rotating cam.

3. BREECH-CLOSING MECHANISM. Bag-type turret guns are fitted with combination spring and pneumatic mechanisms called COUNTERBALANCE AND CLOSING CYLINDERS for counterbalancing the weight of the plug and associated parts hinged to the yoke, and for assisting the plugman in closing the breech. The details of mounting and construction of these devices vary from one type of gun to the next, but in general, as figure 2–7 shows, the spring surrounding each closing cylinder (one on each of the two mechanisms on the 16″ gun) provides the counterbalancing forces on the plug carrier, while air pressure on the closing cylinder pistons pushes the plug to closed position. (On 8″ guns, with their

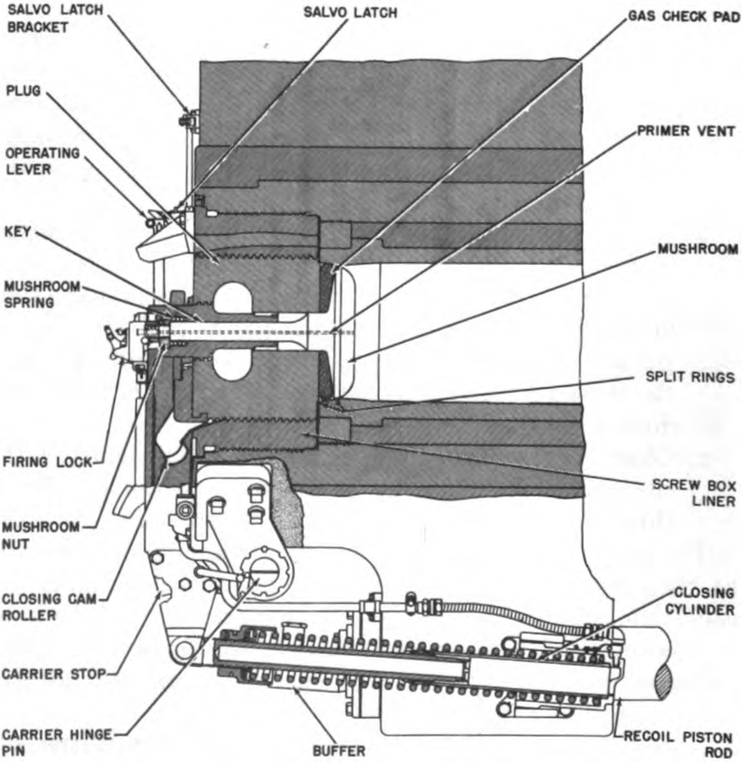


Figure 2–7.—16″ breech mechanism, Mk 4 type. Sectional view.

ighter breech assemblies, one counterbalance and closing cylinder suffices.)

The breech plug is always locked in position, whether open or closed. When open, the plug is locked by the CARRIER HOLDING-DOWN LATCH, which holds the plug down by stiff-leg or toggle action. The latch is released mechanically by a foot lever when the breech is to be closed. (Fig. 2–8.) When the breech is closed, it is locked by the salvo latch and by the engaging screw threads of the plug and screw-box liner.

The compressed air to the closing cylinder is supplied by the gas-ejector system (at about 150 to 200 p. s. i.) through a reducing valve. The pressure of the input air to the closing cylinder is critical. In most bag-type guns now in use, it is adjusted at the reducing valve to a pressure just BELOW that required for the cylinder to close the breech completely without other assistance. In other words, when the air pressure is properly adjusted, the closing cylinder will almost, but not quite, close the breech, so that the plugman must follow through all the way with the operating **lever to close the breech completely.**

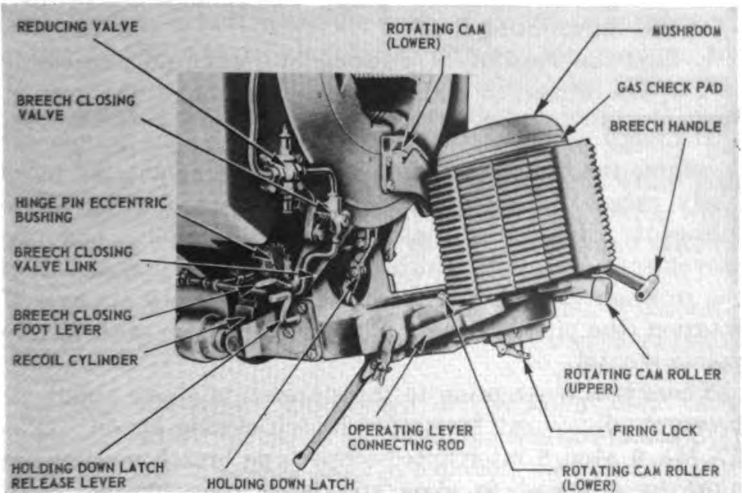

REDUCING VALVE
ROTATING CAM (LOWER)
MUSHROOM
GAS CHECK PAD
BREECH CLOSING VALVE
BREECH HANDLE
HINGE PIN ECCENTRIC BUSHING
BREECH CLOSING VALVE LINK
BREECH CLOSING FOOT LEVER
RECOIL CYLINDER
ROTATING CAM ROLLER (UPPER)
FIRING LOCK
OPERATING LEVER CONNECTING ROD
HOLDING DOWN LATCH RELEASE LEVER
HOLDING DOWN LATCH
ROTATING CAM ROLLER (LOWER)

Figure 2–8.—16" breech mechanism, Mk 4 type. Detail, showing holding-down latch.

In general, the closing cylinder for a clean, properly lubricated, adjusted, and aligned breech mechanism will require a pressure of about 40 p. s. i. to perform this way. At the present time, turret breech mechanisms in active service are fitted with Mason (or, less often, Foster) air-pressure regulating valves. Both these types are adjusted by a square-headed adjusting screw at the top of the valve.

If the air pressure is made too low, breech closure will require excessive effort by the plugman. If it is too high, so that the breech closes completely by itself, the plug may slam shut and damage the mechanism, or—potentially even worse—cause the operating lever to rebound. Experience has shown that this can cause one of the following three dangerous malfunctions:

a. PRIMER BLOWBACK. Operating lever rebounds after firing circuit is closed, opening the firing lock and exposing the primer just as its charge goes off. Parts of the primer stock blast dangerously to the rear.
b. SHEARED PRIMER. Operating lever rebound partially ejects primer, then moves back to latched position. Firing lock is jammed partly closed, shearing primer, and interrupting fire.
c. EJECTED PRIMER. Operating lever rebound completely ejects primer, so that repriming is required.

If breech closing action is erratic even at the proper air pressure, the trouble may be plug misalignment, or more likely excessive friction caused by gummy or inadequate lubricant. Remember that in closing, the plug has two movements—rotation, which depends on camming action of the rotating cam, and forward translation along its axis of rotation (the plug bearing). Proper lubrication of these two points is vital.

There is one exception to the statements above about air pressure adjustment for proper breech closing action. The 8″ Mk 9 Mod 8 interrupted-screw type breech mechanism must be adjusted to close and latch properly by itself, WITHOUT any follow through by the plugman. On all others, you must follow the *BuOrd Manual* requirement that breech closing action be completed by following through manually.

Remember, in any case, that you must NEVER try to compensate for plug misalignment, improper counterbalancing spring adjustment, or faulty lubrication merely by increasing breech closing cylinder air pressure.

4. PLUG COUNTERBALANCING SPRINGS. When properly adjusted, the counterbalancing springs just balance the plug so that as it opens (with the gun at loading position) it will swing down and latch without rebound. If spring compression is too great, it will prevent positive holding-down latch action, and it will be difficult to get the plug to stay down; if compression is insufficient, excessive air pressure will be required to get the breech to close, causing erratic functioning and the other troubles noted above.

5. PLUG ALIGNMENT. The alignment of the plug with the screw-box liner depends on adjusting the carrier hinge. This uses eccentric bushings for bearings, and adjustment of these bushings regulates plug alignment. You can suspect plug misalignment if you see signs of galling and seizing in the engaging threads of the plug and screw-box liner, or if erratic breech action continues even after you have correctly adjusted the counterbalancing springs and air pressure, and have correctly done all the required lubrication. One way you can determine what adjustment is required is to paint lightly the engaging threads of the plug and screw-box liner with a mixture of two parts tallow and one of white lead. Then, open and close the breech repeatedly, observing which areas of the threads show the greatest contact, and shift the eccentric bearings as required to obtain even contact. As a result of this adjustment, you will usually find it necessary to reset closing cylinder air pressure to reduce speed of breech closing.

6. SALVO LATCH. The design of the salvo latch varies from one caliber of bag-type breech mechanism to the next, but the current models have in common the characteristics that all are positive-operation cam-action designs (you will find no more inertia-operated types in service), all require

a deliberate act to release them, and all function by locking the breech operating lever. Salvo latches on bag-type guns have the same function and should be used with the same safety precautions as those on the smaller mounts you are already familiar with.

Bag gun salvo latches have a latch locking arm which will secure the latch in unlocked position when the latch must be made inoperative for drill. The arm is normally positioned in a hole marked "A" for proper functioning of the latch; it is positioned in the other hole, marked "B", to keep the latch unlocked, only for drill. It must be restored to "A" as soon as drill is over.

7. GAS EJECTOR. As in the smaller mounts you are familiar with, gas-ejector systems in bag guns consist of piping (with flexible and expansible joints to permit continuous operation regardless of recoil and gun elevation movement) which conduct air at medium pressure (usually about 150 to 200 p.s.i.) to an automatically opened valve (usually of poppet type); this admits air through passages in the screw-box liner to scavenge the bore and chamber of powder fumes. The main operating differences from the systems you already know are that the poppet valve is cammed open by the opening of the plug, not by recoil or counterrecoil movement; and that the valve is only semiautomatic in action—that is, it opens automatically, but is closed by a crew member pulling on a lanyard.

It is important to repeat here that though the gas ejector hastens clearing the bore and chamber of unbreathable and potentially explosive powder fumes, it is not considered an essential for continued safe operation. But, if not used, the rate of fire will usually have to be reduced.

The *BuOrd Manual* plainly states that the gas ejector "is not a safety feature," and that loading can be done safely with no gas ejecting air PROVIDED THE SAFETY PRECAUTIONS ARE OBSERVED. This means especially that powder bags must not be exposed or loaded until "BORE CLEAR!" is given, and that the bore clear signal must be given only after the bore and chamber have been inspected and found completely clear of fumes, sparks, and smoldering fragments of bag fabric or powder.

Since the gas ejector is not a safety feature, it is also noteworthy that the prescribed safety precautions are necessary (including the bore clear inspection and all the rest) regardless of its functioning or nonfunctioning.

8. GAS-CHECK ASSEMBLIES. The important components of the gas-check assembly are the mushroom, the pad, the split rings, and the gas-check seat. As you no doubt remember, propellant gas pressure on the mushroom head pushes it back so that it squeezes the doughnut-shaped pad against the gas-check seat at the breech end of the chamber, preventing gas leakage to the rear.

Until a few years ago, gas-check pads were made of a mixture of tallow and asbestos fiber, molded into shape under pressure, tightly covered with canvas, and usually provided with copper protectors to keep the steel split rings from cutting the canvas. The pad was inelastic and hard to the touch, but it could be softened by heat; the wear, tear, and extremes of temperature incident to firing eventually softened and deformed such pads and rendered them unfit for further use.

The gas-check pads now in use are made of neoprene and other synthetics whose characteristics have eliminated these drawbacks. Though they are elastic, rather than hard, they keep their shapes as originally molded, and they resist temperature changes, rough handling, high pressures, and abrasion. Oil and moisture do not have bad effects on them. With reasonable care in installation and maintenance, they can be expected to last substantially as long as the guns in which they are installed.

These pads are packed with their split rings in sealed containers in which they should remain until installation. When installing a pad, first inspect the rings for gouges, burs, and deformation, and inspect the pad for cuts, as soon as they are removed from the container. Remove preservative, coat the rings, breech plug face, and both faces of the pad with breechblock lubricant (OS 1165), and install.

Carefully adjust the mushroom nut to proper tension. Coat the gas-check seat with machinists' blueing or with chalk, and carefully close and open the breech; examine the seat and pad to make certain that the pad makes contact over the entire gas-check seat, as evidenced by the distribution of the blueing or chalk deposit.

Failure to obtain good pad seating may be caused by improper mushroom nut tension, permitting a split ring to slip off-center. Since the life of the elastic pad, when properly installed, is believed to be at least equal to the life of a gun or liner, the time and effort expended in obtaining the best possible fit during original installation will be well spent.

Note that the copper pad protectors necessary with old-type canvas-covered pads are not necessary with the elastic type of pad.

If the pad is properly fitted, the only routine maintenance required will be renewal of breechblock lubricant as prescribed above. Minor cuts and chafing will not require replacement of the pad, but it is best to be sure that there are no defects in the rings that might cause them.

Spare pads should be inspected periodically in accordance with OP 1419, which also contains information on reporting defective pads.

In connection with fitting of gas-check pads, note that pads bearing the label PROOF SIZE are NOT to be used in service guns. Do not try to install such pads in guns in the fleet. Numerals molded into the rear face of each pad identify it as to drawing and piece number, serial number, and date of manufacture. The size of the gun for which the pad is designed is also stenciled on the pad rear face.

Safety precautions require that the mushroom be wiped after every shot, but it is important to use only a SLIGHTLY moist sponge or cloth, and to be especially careful to keep water and all other foreign matter out of the primer vent.

The gas-check seat must be free of nicks, scores, gouges and other defects that will permit gas leakage.

Although the mushroom stem is a heavy steel component, it can be bent, particularly if the mushroom head is struck near the edge. This can happen when your crew is unloading a drill projectile. To avoid this, first of all train the turret fore and aft, to prevent the projectile from breaking loose unexpectedly when the ship rolls. Then elevate the gun, and unseat the drill projectile while the complete dummy powder charge is in the chamber to absorb the impact of the projectile. Finally, depress the gun to loading position and draw the projectile out by its eyebolt.

An alternative method is to use, instead of the dummy propelling charge, a buffer made up in the form of a medicine ball, but big enough to reach well beyond the center of the mushroom, so that the impact of the projectile will be transmitted to the central portion of the mushroom. OP's on bag-type guns recommend old boat falls covered with canvas as good material from which to make such buffers.

9. FIRING LOCKS. All bag-type turret guns now use the Mk 14 firing lock. You should already be acquainted with the construction and functioning of this device from the Navy training course for Gunner's Mate Third. Here are some notes about its safe use and upkeep:

a. If they are kept mounted in the breech plug, firing locks should be inspected and thoroughly cleaned weekly (use alcohol or gasoline).

b. Never use heavy lubricant in a firing lock. Keep ALL lubricants away from electrical contacts.

c. Replace all parts that have been galled or burred or show excessive wear.

d. Make sure the extractor is not sprung; a sprung or distorted extractor will jam the firing lock.

e. The lanyard must NEVER be attached to the cocking lever unless the gun is to be fired immediately by percussion.

f. When inserting a primer, push it all the way home, beyond the primer retaining catch, or the primer may come part way out and be sheared. And, once the primer has been inserted and the lock closed, do NOT attempt to remove it before firing without opening the firing circuit and removing the electrical firing lead.

We have considered common upkeep operations for the bore, chamber, and breech mechanisms of bag-type turret guns, particularly as they differ fundamentally (in respects other than the mere size or minor design details of the parts concerned) from those weapons you are already familiar with. Your primary reference for details of all maintenance operations in a specific turret should be, of course, the OP for the equipment; the discussion in this chapter has introduced you only to typical gun upkeep operations. You will, as you continue to study publications on turret weapons, find many familiar features, and some that are different. Review the survey of turret installations in the GM3 Navy training course along with the OP's for the equipment you are expected to know.

Upkeep for other types of ordnance for which you are specifically responsible as a GM1 or GMC is reviewed in the other chapters of this course that deal with them.

Let us now go on to consider the Navy's system for dealing with repair of ordnance equipment.

REPAIRS

What does the Navy mean by the term "repair"?

The term REPAIR, as applied to naval equipment and defined in *Navy Regulations*, means "work necessary to restore a ship or article to a serviceable condition, without change in design, materials, number, location, or relationship of the component parts." This means that when you make repairs you put the ship or equipment into running order, without changing design in any way, and replace parts with like parts. And that's all it means. Note that the definition specifically excludes any changes or ALTERATIONS because those are a different kind of thing altogether, which we shall discuss later in this chapter.

Repairs are classified by priority, in descending order, as EMERGENCY, URGENT, ROUTINE, and DEFERRED. They are also classified by the agency performing them as SHIP'S FORCE, TENDER or REPAIR SHIP, and SHIPYARD or NAVY YARD. You are already familiar with these categories from earlier courses in this series.

This classification also reflects the difficulty of the work. Ship's force is expected to perform all minor alterations and minor repairs, including replacements and adjustments; the facilities, experience, and skilled personnel of repair ships, tenders, and yards are needed for work requiring resources superior to those of the ship's force. Some or all of the ship's force—leading Gunner's Mates, for example, on ordnance equipment—will be expected to work along with tender, repair ship, and yard personnel.

Your Responsibilities in Repair

In general, your main job will be to organize and direct shipboard repair and overhaul facilities, and to train your men so that emergency repairs aboard ship can be made quickly. Generally speaking, the repairs you can make aboard ship are limited by the tools and equipment at your disposal, and what you have at your disposal is dependent upon the guns and other ordnance equipment aboard. When repairs are necessary, it will be your main job to diagnose the casualty. But you will personally make repairs to more complicated mechanisms, such as hydraulic equipment.

You need at least three important skills to do your job well. You need skill in using hand tools, oftentimes in small and confined spaces; you need skill in following complicated step-by-step procedures in breaking down equipment for repair; and you need skill in supervising and directing repair work.

You will have tools and spare parts for your equipment, and ordinarily your repair jobs will be confined to replacing worn or broken parts with new ones. All tools and accessories are supplied in boxed sets, each special purpose set containing items needed to service the elements of a specific assembly or subassembly.

It is your job to take care of your tools and to be sure you have your full allowance of spare parts on hand. Chapter 10 contains instructions for obtaining spare parts and equipage, and discusses the paper work involved.

Your success in repair work depends largely on your obtaining plenty of experience on actual repair jobs. Often such jobs will be emergency jobs, and you must be ready for them. At other times, you can solve your problem by making out a work order for repair ship or tender repairs, but even then you'll have to perform a casualty analysis. It won't be enough merely to ask for "such repairs as are necessary," or "overhaul as needed." Your work order must ask for specific and definitely described repair jobs.

Repair Ship and Navy Yard Availabilities

Repair facilities like Navy yards, tenders, and repair ships are expensive necessities. They are expensive in first cost and expensive to keep up. But they are necessary to keep our complex modern Fleet in fighting trim. The Navy's problem is, on the one hand, to have enough of these facilities to keep the Fleet at top effectiveness, and on the other to use these facilities at full efficiency, so that they are working (not idle), and so that they are doing the work they are designed for (not work that could be done by the ship's force).

This problem boils down to a matter of scheduling. In peacetime, normally, most ships are serviced periodically by Navy yards, tenders, and repair ships.

These AVAILABILITIES, or periods of overhaul and repair, are scheduled well in advance, and during them it is up to you as a leading Gunner's Mate to take full advantage of the skilled personnel and special repair facilities available for the benefit of the equipment for which you are responsible.

The detailed paperwork involved in preparing for these repair facility availabilities is discussed elsewhere in this course. Here, let us consider your responsibilities as a leading Gunner's Mate with regard to repairs, both those performed by ship's force and those done in cooperation with Navy yards, tenders, and repair ships.

Repair Ships and Tenders

Both repair ships and tenders are especially fitted for performing complicated jobs which are beyond the facilities of shipboard personnel and equipment. Such ships carry highly trained personnel and special repair equipment.

Repair ships fall into several different classes:

Repair ship (AR)
Battle damage repair ship (ARB)
Internal combustion engine repair ship (ARG)
Heavy hull repair ship (ARH)
Landing craft repair ship (ARL)
Salvage vessel (ARS)
Salvage lifting vessel (ARS (D))
Salvage craft tender (ARS (T))

Tenders fall into three classes: destroyer tenders (AD's); submarine tenders (AS's); and motor torpedo boat tenders (AGP's).

As far as repairs to ordnance equipment are concerned, you will be chiefly interested in repair ships—AR's. These vessels have shops which carry all the components necessary for hull, machinery, electrical, and ordnance repairs for capital ships. However, destroyer tenders—AD's—also carry enough equipment to make repairs to ordnance equipment aboard smaller ships.

The difference between repair ships and tenders lies largely in the fact that repair ships are designed for maintenance only, whereas tenders support their attached ships in all respects. Repair ships carry general maintenance facilities and repair parts, but tenders carry facilities especially for one type of ship. Both types of ships have many features in common, however, and many items of identical repair equipment.

On repair ships, the repair officer is detailed to head the repair department. He is responsible for the following duties:

1. Preparation of repair schedules.
2. Supervision and inspection of repairs and services.
3. Preparation of reports, forms, and orders in connection with his duties.
4. Cleanliness and upkeep of spaces assigned.

The Repair Department

The repair department aboard a typical repair ship might be set up as follows (each division is headed by an assistant repair officer):

Hull Division

- Blacksmith shop
- Canvas shop
- Carpenter shop
- Diving and salvage
- Gas mask repair shop
- Pipe and copper shop
- Rigging
- Sheet metal shop
- Shipfitter shop
- Welding shop

Machinery Division

- Boat engine repair shop
- Boiler shop
- Foundry
- Gage shop
- Hydraulics shop
- Machine shop
- Machinery section (outside)
- Pattern shop
- Refrigerator repair shop

Electrical Division

- Battery repair shop
- Electrical repair shop
- Electrical instrument shop
- Electronics shop
- Gyro compass repair shop
- Sound motion picture repair shop

Technical Division

- Cryptographic repair facility
- Fire control shop
- Optical and rangefinder shop
- Ordnance repair shop
- Photo and blueprint laboratory
- Plating shop
- Print shop
- Typewriter repair shop
- Watch repair shop

A repair department aboard a tender might be set up in a similar fashion. One typical tender has four divisions in its repair department: a construction division, an electrical division, a mechanical division, and an electronics division. The various shops fall into one or another of the main divisions.

It is possible that a repair job might be given over to several of the shops aboard a repair vessel or tender, but the shop which would ordinarily handle ordnance repairs would be the ordnance shop. On a typical repair vessel, these are the types of jobs which could be performed by the ordnance repair shop:

Repairs to gun mechanisms
Repairs to gun mounts
Repairs to gas ejector systems
Boresighting
Stargaging
Facing off gun liner protrusions

The following guns and mounts could be repaired:

All small arms
Gun mechanisms, 20 mm to 5″/38
Gun mounts, 20 mm and 40 mm
Barrels removed and replaced, 40 mm to 5″/38
Mounts lifted, up to 5″/38

Equipment in the shop would consist of most (or all) of the following:

Limited quantities of spare parts
Barrel wrenches, 3″/50 and 5″
Bearing press, hand arbor, bench type
Boresights, 20 mm to 5″
Drill press, 16″ x ½″ drill size
Electric hoist, 3,360-pound capacity
Facing off tool, for guns up to 16″
Fleet stargage, 3″ to 16″
Lathe, South Bend, 10″ x 18″
Special tools, 20 mm to 5″ guns
Vises, bench, size up to 4″ jaw
Welding equipment, acetylene

Various types of ordnance equipment might be sent to other shops, of course, such as the hydraulic shop, the electrical shop, or the machine shop. The hydraulic shop could repair and adjust train and elevation units, controls of indicator- and receiver-regulators on guns and directors, and hydraulic motors and pumps.

Work Requests

The complete repair schedule, as well as the flow of work to the proper shops, is the responsibility of the repair officer aboard the repair ship. It is your job to fill out the necessary work requests.

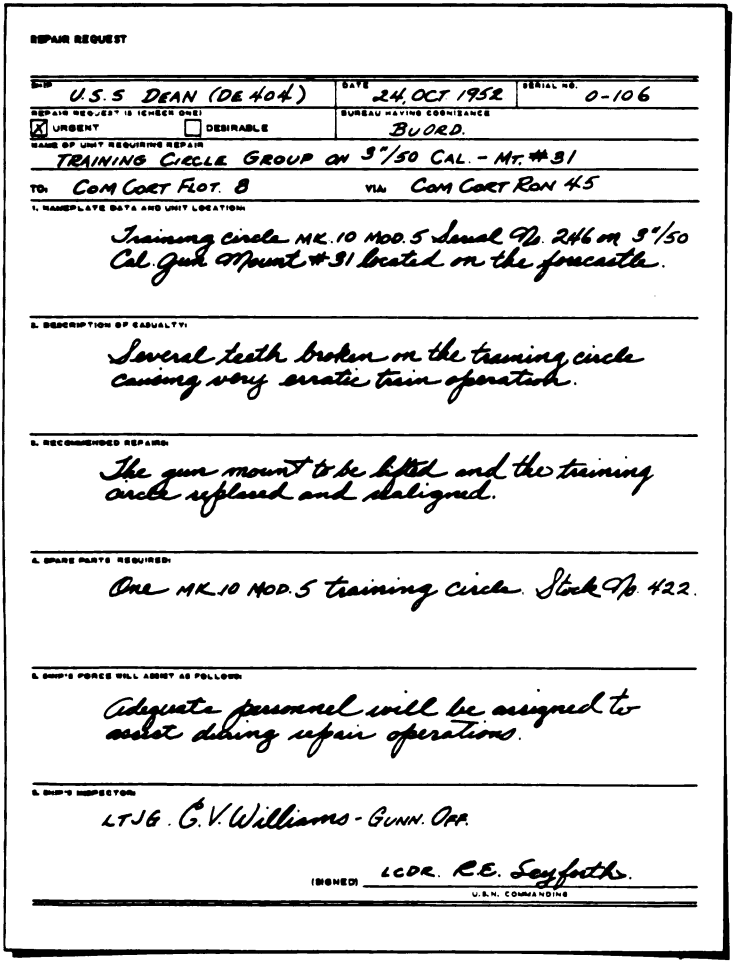
Work requests are just what the words imply—requests that certain work be done. The requests may be made to tenders or Naval shipyards when the work is beyond the scope of the ship's personnel.

The form used to prepare a work request will vary from ship to ship. There is no standardized form in Navy-wide use. A typical work request form is shown in figure 2–9. A work request should include, as a minimum, the following information:

1. The date and ship from which sent.
2. The activity performing the work.
3. Bureau under whose cognizance the work falls.
4. The class or priority of work requested. (Urgent, Desirable, and so forth.)
5. A complete outline of the work to be done. A request that is vague or indefinite and uses such expressions as "Do work where necessary" is not considered to meet the requirements of a good work request.
6. Assistance to be furnished by ship's force. Some commands also require a statement that the work is not within the power of the ship's personnel to perform.
7. The signature of the department head submitting the request, and of the ship's captain.

Each work request should be restricted to items under the cognizance of a single bureau and the items to one of the following classes: URGENT REPAIRS, DESIRABLE REPAIRS, and ALTERATIONS.

Work requests should be made out and submitted as far in advance of the availability period as possible, but provision is usually made for submitting emergency work requests.



REPAIR REQUEST

SHIP U.S.S DEAN (DE 404)	DATE 24, OCT. 1952	SERIAL NO. 0-106
REPAIR REQUEST IS (CHECK ONE) ☒ URGENT ☐ DESIRABLE	BUREAU HAVING COGNIZANCE BuORD.	

NAME OF UNIT REQUIRING REPAIR
TRAINING CIRCLE GROUP ON 3"/50 CAL. - MT. #31

TO: COM CORT FLOT. 8 VIA: COM CORT RON 45

1. NAMEPLATE DATA AND UNIT LOCATION:
Training circle MK. 10 MOD. 5 Serial No. 246 on 3"/50 Cal. Gun Mount #31 located on the forecastle.

2. DESCRIPTION OF CASUALTY:
Several teeth broken on the training circle causing very erratic train operation.

3. RECOMMENDED REPAIRS:
The gun mount to be lifted and the training circle replaced and realigned.

4. SPARE PARTS REQUIRED:
One MK 10 MOD. 5 training circle. Stock No. 422.

5. SHIP'S FORCE WILL ASSIST AS FOLLOWS:
Adequate personnel will be assigned to assist during repair operations.

6. SHIP'S INSPECTOR:
LTJG. C. V. Williams - GUNN. OFF.

(SIGNED) LCDR. R.E. Seyforth.
U.S.N. COMMANDING

Figure 2-9.—Typical work request form.

Ordinarily, a work request is submitted to the appropriate command, which assigns the work to a repair ship or tender and establishes a priority for the work.

For further information on work requests, see *Navy Regulations* (1948 revised), chapter 20.

After a repair job is completed, you must check it carefully for any defects BEFORE it is approved and accepted. If you discover something wrong, make an IMMEDIATE report. It won't do you much good to find casualties after your repair ship availability period has ended.

After the repair is completed and accepted, record it in the Ordnance Machinery History, as described later in this chapter.

ALTERATIONS

So far we have been considering repair in the strict sense of merely restoring equipment to serviceability, without change in its characteristics. But ordnance equipment design is never completely "frozen"; for reasons of safety, improved performance, longer endurance, and so forth, design changes are made from time to time. As you read in the preceding article, these changes are in general known as ALTERATIONS.

Navy Regulations define an ALTERATION as "any change in the hull, machinery, equipment, or fittings which involves a change in design, materials, number, location, or relationship of the component parts of an assembly regardless of whether it is undertaken separately from, or incidental to, or in conjunction with, repairs." Alterations may be made only if specifically authorized by the bureau concerned (in this case, BuOrd).

Alterations great enough to modify the military characteristics of a vessel must be authorized by the Chief of Naval Operations. When so authorized, instructions for them are issued by the bureau having cognizance over the material concerned, as serially numbered NavAlts. Other alterations to ordnance material are issued by BuOrd as serially numbered OrdAlts. Both OrdAlts and NavAlts contain the following information:

1. Purpose of the alteration.
2. Authority for the alteration.

3. Urgency classification (priority). Alterations may be classified as EMERGENCY (highest priority), URGENT, ROUTINE, and DEFERRED.
4. Vessels and stations to which applicable.
5. Applicable drawings. These are usually printed and distributed as part of the OrdAlt.
6. Source and supply of material.
7. Allowance list changes and spare parts furnished.
8. By whom performed (that is, ship's force, tender, and so on).
9. Instructions for accomplishing work.
10. Mod changes. Alterations often require changes in designation, but not always.
11. Disposition of replaced material.
12. Change of weight involved.
13. Reports of completion.
14. Distribution lists.

Specific OrdAlts may vary in detail from this exact outline, but you can expect to find this information under similar headings in all of them. For further details on how OrdAlts are made up, see OSTD 65, entitled *OrdAlts: Preparation, Issue, and Accomplishment.*

The Bureau of Ships has a similar alterations system applying to material under its cognizance. Such alterations are called SHIPALTS.

The Navy maintains strict control over all alterations to its equipment. There are a number of reasons for this. An important one is that the Navy is interested not only in improving its equipment but also in keeping it standardized, so that any item of a given mark and mod is exactly the same as every other item of that mark and mod. This means that any change or improvement in one item must be applied equally to all others of the same mark and mod. Moreover, it is important to maintain interchangeability of parts, and to ensure that no alteration reduces equipment performance characteristics or complicates supply problems.

So the Bureau of Ordnance has a system of reports, which in combination with the priority classification referred to above enables it to keep close track of the alterations made on all ordnance equipment.

In the active fleet, the gunnery officer (or someone he designates—perhaps you, as leading Gunner's Mate) fills out an ORDALT COMPLETION REPORT CARD (illustrated in fig. 2–10), which the skipper forwards to the type commander and to BuOrd upon completion of the alteration.

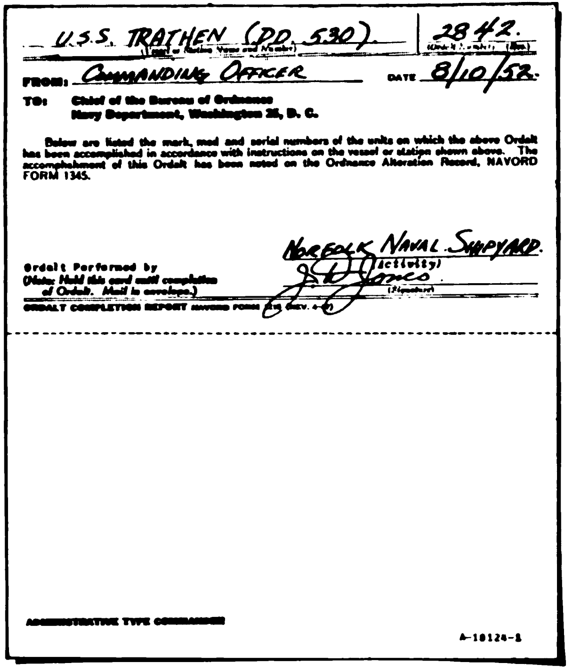
As you can see from the figure, you fill out BOTH parts of the card, then separate the two parts along the perforations, and forward the respective parts to the administrative type commander and to the Bureau of Ordnance. Note that the report is NOT to be mailed until the alteration work is satisfactorily completed.

With these completion reports, the Bureau can keep track of the progress of each ordnance alteration throughout the Fleet. When all applicable equipment has been reported as altered in accordance with a specific OrdAlt, that OrdAlt can be withdrawn. OrdAlts and NavAlts still in effect are listed in the publication NavOrd OrdAlt 00, which is revised and reissued annually. OrdAlt 00 also contains a checklist of completed OrdAlts, and instructions on the distribution and application of OrdAlts.

Some record of OrdAlts completed is necessary also for your own ship, both to avoid duplication and to ensure that all equipment to be modified is actually modified. The record of alteration is kept in two forms:

1. In the ordnance machinery history. (This record supplants old NavOrd Form 1345.)
2. On OrdAlt plates.

The way in which you record alterations in your Ordnance Machinery History is taken up later in this chapter. As for OrdAlt plates, they are metal plates physically attached to the equipment near the name plate. They are headed ORDALTS ACCOMPLISHED, show the mark, mod, and serial numbers of the equipment, and contain small blank rectangles on which will be engraved the numbers of OrdAlts actually accomplished. When all the blanks on a plate are occupied,



U.S.S. TRATHEN (DD 530). | 2842.
(Vessel or Station Name and Number) | (OrdAlt Number) (Rev.)

FROM: COMMANDING OFFICER DATE 8/10/52.

TO: Chief of the Bureau of Ordnance
Navy Department, Washington 25, D. C.

Below are listed the mark, mod and serial numbers of the units on which the above Ordalt has been accomplished in accordance with instructions on the vessel or station shown above. The accomplishment of this Ordalt has been noted on the Ordnance Alteration Record, NAVORD FORM 1345.

Ordalt Performed by
(Note: Hold this card until completion of Ordalt. Mail in envelope.)

NORFOLK NAVAL SHIPYARD.
(Activity)

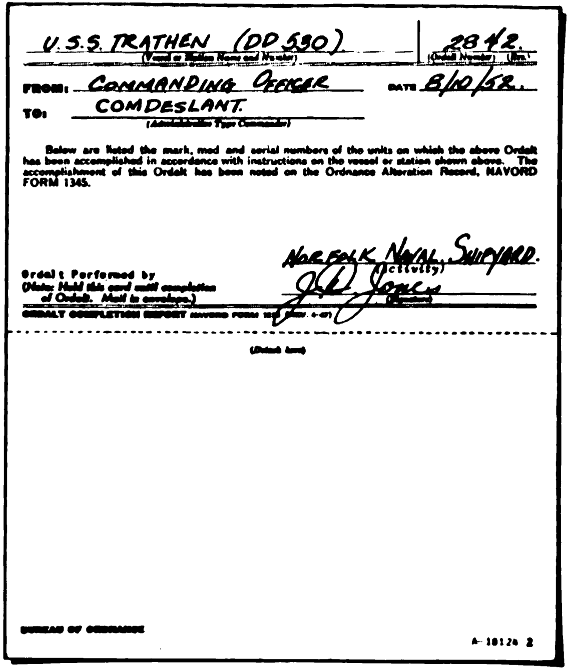
J. D. Jones
(Signature)

ORDALT COMPLETION REPORT NAVORD FORM 1215 (REV. 4-47)

ADMINISTRATIVE TYPE COMMANDER

A-10124-1

FRONT



U.S.S. TRATHEN (DD 530). | 2842.
(Vessel or Station Name and Number) | (Ordalt Number) (Rev.)

FROM: COMMANDING OFFICER DATE 8/10/52.

TO: COMDESLANT.
(Administrative Type Commander)

Below are listed the mark, mod and serial numbers of the units on which the above Ordalt has been accomplished in accordance with instructions on the vessel or station shown above. The accomplishment of this Ordalt has been noted on the Ordnance Alteration Record, NAVORD FORM 1345.

Ordalt Performed by
(Note: Hold this card until completion of Ordalt. Mail in envelope.)

NORFOLK NAVAL SHIPYARD.
(Activity)

J. D. Jones
(Signature)

ORDALT COMPLETION REPORT NAVORD FORM 1215 (REV. 4-47)

(Detach here)

BUREAU OF ORDNANCE

A-10124 2

BACK

Figure 2-10.—OrdAlt Completion Report (NavOrd Form 1215).

you will have to fasten new plates to the equipment. Do NOT discard the old plates, or cover them with the new ones. When installing OrdAlt plates, be careful to avoid getting chips and shavings into the equipment.

OrdAlt plates come in two sizes; the smaller (shown in fig. 2-11) contains 12 blanks and the larger 36. There is also a combination name plate and OrdAlt plate containing eight blanks for OrdAlts.

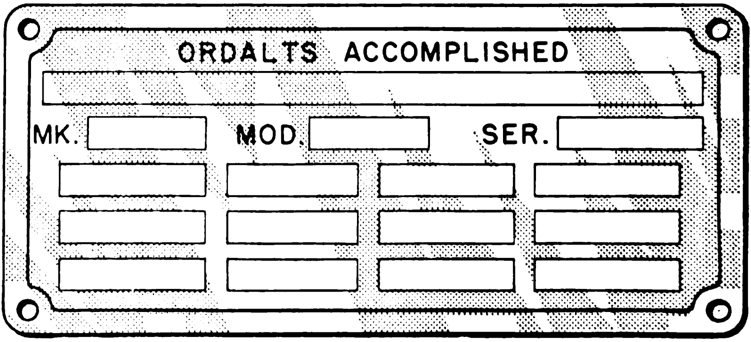


Figure 2-11.—OrdAlt plate (small size).

The plates are intended for use only on equipment that normally carries name plates with mark, mod, and serial numbers, such as major components of gun mounts and turrets, fire control instruments, and the like. These OrdAlt plates are NOT to be applied to ammunition of any kind (and this includes depth charges, mines, and torpedoes), small arms, aviation ordnance equipment, or small items like switches, synchros, relays, firing keys, and so on. Nor do the plates have to be applied to any equipment prior to the completion of the first OrdAlt. However, if you have equipment that has had OrdAlts completed on it, but has no OrdAlt plates, make sure the plates are made up to record all completed OrdAlts and are attached to the equipment.

Note that BOTH of these OrdAlt records must be kept. Neither one of them substitutes for the other, or for the OrdAlt completion card that is to be sent to the Bureau of Ordnance.

Field Changes and Alterations Equivalent to Repair

There is a sort of twilight zone between repairs and alterations in which belong certain repair operations which involve more than merely restoring the equipment to efficient operating condition according to its original design. Such an operation might be, for example, replacing a part with one of different material or of more efficient design, or strengthening of parts, or making minor changes to prevent recurrence of certain casualties or to prevent damage to the ship's structure. Alterations equivalent to repair are promulgated by BuOrd through Ordnance Material Letters (OML's).

In any case, alterations equivalent to repair must never involve any increase in weight.

FIELD CHANGES are alterations that apply only to radar gear and similar electronic equipment. They are recorded in the Machinery History as OrdAlts are. They are reported on NavOrd Form 1830 (not illustrated), not on Form 1215.

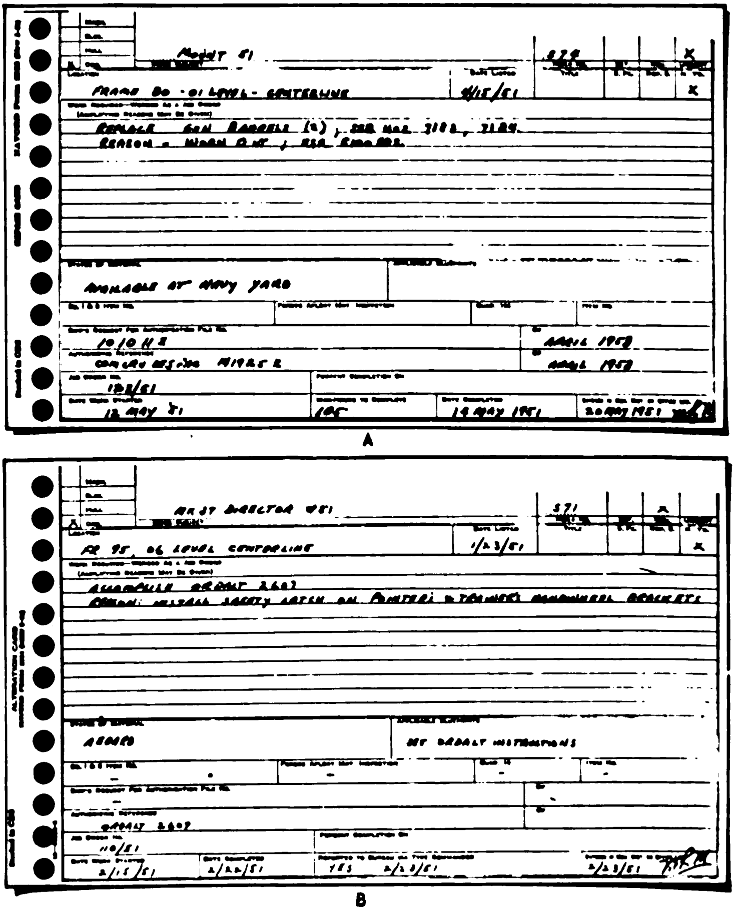
CSMP

So far in this chapter we have taken up the three major activities that you are concerned with in ordnance maintenance.

The repair and alterations phases of the maintenance of the ship are consolidated in one group of files—the CURRENT SHIP'S MAINTENANCE PROJECT, usually known by its initials as CSMP. The standard CSMP system for ordnance equipment is officially described in OP 1887. But it's worth a light once-over here.

In general, you can think of the CSMP file as being a record of future alterations and repairs. It usually lists jobs that are to be done when the ship is alongside a tender or repair ship, or at a Navy yard. This does not necessarily mean that each job listed in the CSMP is beyond the capabilities of the ship's force (though some of them may be); it includes all repairs and alterations to be accomplished, whether by ship's force or by other repair personnel.

The CSMP provides the Gunnery Officer with the data he needs for the systematic repair and alteration of ordnance equipment. It is especially useful in preparing work requests. You should note, by the way, that the CSMP in no way supplants the Ordnance Machinery History described later in this chapter. The CSMP applies only to equipment requiring repair or alteration, while the Ordnance History applies to ALL ordnance equipment.



MOUNT 51

FRAME 80 - 01 LEVEL - CENTERLINE

4/15/51

REPLACE GUN BARRELS (2), SER NOS 3108, 3129.

REASON - WORN OUT, [illegible] [illegible]

AVAILABLE AT NAVY YARD

1010 HX

APRIL 1952

[illegible] [illegible] [illegible]

APRIL 1952

182/51

12 MAY 51

105

14 MAY 1951

20 MAY 1951

A

MK 37 DIRECTOR #51

571

FR 95, 06 LEVEL CENTERLINE

1/23/51

ACCOMPLISH ORDALT 2607

REASON: INSTALL SAFETY LATCH ON POINTER'S & TRAINER'S HANDWHEEL BRACKETS

[illegible]

SEE ORDALT INSTRUCTIONS

ORDALT 2607

110/51

2/15/51

2/22/51

YES 2/23/51

2/23/51

B

Figure 2-12.—CSMP cards. A. Ordnance repair card. B. Ordnance alteration card.

CSMP records are maintained on NavOrd Forms 2033 and 2034, which are used, respectively, for recording repairs and alterations. These forms fit into a loose-leaf binder file. You have the forms filled out when a repair or alteration is required. Make an individual card for each repair or alteration. File them by equipment name and number, within the following categories:

1. File repair cards in two categories, depending on whether the equipment is under the cognizance of BuOrd or BuShips.
2. File alteration cards within four categories:
    a. OrdAlts.
    b. ShipAlts (including BuShips letters). These may be associated with OrdAlts, or with equipment (such as dredger hoists) under BuShips cognizance but supervised by the gunnery department of the ship.
    c. Ordnance Field Changes
    d. Ordnance Material Letters.

It may happen that a ship will originate plans for an alteration. Copies of these plans and all other pertinent information concerning the proposed alteration should then be entered on the alteration card and filed, awaiting approval of the Bureau of Ordnance. When approved such alterations are not OrdAlts, since they are authorized by letter from the Bureau of Ordnance, and since they apply to only one ship or to a limited number of ships on a more or less experimental basis.

An effective CSMP system, provided it is kept up to date, simplifies the preparations for an overhaul period. In addition, as each job is completed, the cards can be used in writing up the machinery history. They are then filed as a reference for as long as deemed necessary, or at least for a year.

A. & I. PROGRAM

The Alteration and Improvement Program (more briefly, the A. & I. program) is a list or schedule of applicable alteration work to be done which is to be charged against U. S. Navy appropriated funds. It is distributed periodically (usually quarterly) to all active ships of the Fleet through type commanders. One section of the list distributed to each ship shows ordnance work items; the gunnery officer reviews this section and annotates it to bring it up to date. As leading Gunner's Mate, you may be called upon to assist the gunnery officer in correcting this list to show the current status of all alterations. After this revision, the skipper forwards the list to the type commander, who uses it for planning and administrative purposes.

To keep both the CSMP and the A. & I. program up to snuff, it is up to you to keep close track of the status of all maintenance work (especially alterations and repairs) and to keep all battery logs, machinery histories, and other current records accurate and up to date. Details for maintaining them are contained in applicable fleet and type command letters.

REPORTS

So that the demand for equipment, supplies, and spare parts can be accurately anticipated, the Bureau of Ordnance has to know the location and condition of every piece of ordnance equipment in service, and the actual count of spare parts, supplies, etc. That means reports—plenty of them.

This course gives you a good review, especially in chapters 2 and 10, of the more important reports that you are expected to dig up the information for. But reports change frequently. Some drop out, new ones appear, and the forms are often revised. You will have to keep up with these changes because, as First Class or Chief Gunner's Mate you will be responsible for supplying the correct information. The job of making out the smooth form falls to the Yeoman, but you must know when the reports are due and what information they require. It is up to you to find out from the gunnery office what reports are needed, and when.

Reports are no good unless they are absolutely accurate. That's up to you. Collect the information from actual inventory and from checking the actual parts for the mark, modification, and serial numbers. Each time a report is due, check again; do not copy the data from the file carbons of previous reports.

For instance, if a gun and gun mount are to be transferred from the ship, the Gunner's Mate in charge should copy accurately the desired information from the plates on the different parts. Likewise, in making annual reports the information should be taken from the ordnance material to be reported and this information then given to the gunnery officer so that the reports can be made out correctly.

Performance Reports

Reports of casualties to ordnance equipment form a necessary part of the reports of gunnery exercises, which are submitted to the Chief of Naval Operations. These eventually furnish the Bureau of Ordnance with information on the malfunctioning of ordnance gear.

However, there are cases where ordnance equipment, although being operated as designed, malfunctions or shows inherent weakness. When this happens the Bureau of Ordnance ought to be informed promptly, as final responsibility for any corrective action lies with the Bureau. A report of the above conditions will be made to the Bureau IN ADDITION to the reports included in the normal or routine reports of gunnery exercises.

This report is submitted when the exercises occur. It is your responsibility to furnish the basic information to the gunnery officer, who will draw up the report in final form.

OTHER MAINTENANCE RECORDS

The two basic continuing records kept in the gunnery department are the ORDNANCE LOGS and the ORDNANCE MACHINERY HISTORIES.

Ordnance Logs

An ordnance log is a book in which you record chronologically information concerning tests, overhauls, repairs, alterations, and maintenance work on certain ordnance equipment.

Why keep an ordnance log?

An ordnance log serves two purposes. First, it gives the Bureau of Ordnance a complete accounting of the operation of the equipment. Such logs, over a period of years, help to shape the policy of the Bureau as to the design of parts and the types of material used.

Second, a well kept ordnance log is handy to YOU as a casualty reference. If a casualty occurs that has happened before, the log can be consulted for the method of repair previously used. If a certain type of repair has proved unsatisfactory, repetition of that method can be prevented by referring to the log. When a new man takes over a gun mount he can refer to the log and become familiar with the mount's peculiarities in a short time.

Logs may be either typewritten or legibly handwritten. A handwritten log should be kept in a bound notebook; use a loose-leaf or post binder for a typed log. For some equipment printed log forms are available; use them. But it is important, whatever else the log contains, to make the entries EVERY day, to make them legible, complete, and neat, to date each entry (naturally, the entry is to be made the day it's dated), to keep the entries in chronological sequence, and to keep the logbook with the equipment. It's a good idea for the writer to initial his entries. Except with printed log forms, no special arrangement for each entry is prescribed. Make all entries uniform; if you begin by putting the date at the head, for example, keep doing that in all subsequent entries. Enter numerical data in tabular form. If there is nothing to enter for the day, the writer just jots down the date and his initials.

The logs most important to you as a leading Gunner's Mate are the battery log, the small-arms log, the ballistics log, the magazine temperature record, and the ammunition record.

Battery Logs

At present, BuOrd minimum requirements call for maintenance of the following battery logs:

Turret logs	1 per turret
5″ mounts	1 per mount
3″ RF mounts	1 per mount on BB, CA, CB, CL, CLAA, CVA, and CVL; 1 per battery on others
3″ semiautomatic single mounts	1 per battery
40 mm mounts	1 per battery
20 mm mounts	1 per battery
A/S launchers	1 per type of launcher
Rocket launchers	1 per battery

What goes into the battery log?

Broadly speaking, everything that happens to, is done to, or is done with the equipment, except for cleaning and for specific routine items appearing on check-off lists, goes into the battery log. Here is a fairly comprehensive list of just what this can include:

1. Drills and exercises involving equipment.
2. The execution of routine, pre-firing, and post-firing check-off lists. (This means that you indicate that the items on such-and-such a check-off list have been taken care of. It is NOT necessary to specify each individual item in the log.)
3. Any use of lubricants different from those specified, and reasons therefor.
4. Conduct and record of tests, checks, measurements, and megger readings.
5. Conduct of special inspections.
6. Summary of maintenance not covered by check-off lists, such as: adding hydraulic oil (give quantity and type); filling, flushing, or draining of hydraulic units

or water jackets; tightening or check of all bolts and nuts; lifting of equipment for inspection; boresighting; and stargaging.

7. Adverse effects of weather on material maintenance or operation.
8. Detailed description of casualties—giving name, mark, mod, serial number, and part number of unit and part involved, what happened, probable cause, how repaired, and steps taken to prevent recurrence.
9. Summary of repairs made, including complete identification of part or parts affected, parts replaced, and probable cause.
10. Brief summary including number of any pertinent OrdAlt, ShipAlt, Field Change, or Bureau authorized modification performed.
11. Report of hit or damage to equipment from outside source.
12. Record of tram readings, roller path compensator readings, and erosion indicator readings.
13. List of major units or subassemblies of mounts, including mark, mod, serial number. (This list should be in the first pages of the log and is intended to aid the log keeper in proper identification of units of equipment.)
14. Transfer and receipt of torpedoes and mines.
15. Firings, including details of ammunition used.
16. Rounds fired, quantity, type, date, occasion, and Equivalent Service Round, should be kept in tabular form, by serial numbers.
17. Hours of operation of main systems and prime movers are kept in tabular form.
18. Boresighting results.

Small-Arms Log

One small-arms log is required on each ship. It should list the serial numbers of the small arms on board. Entries should include casualties, modifications, results of inventories, and location of normal stowage.

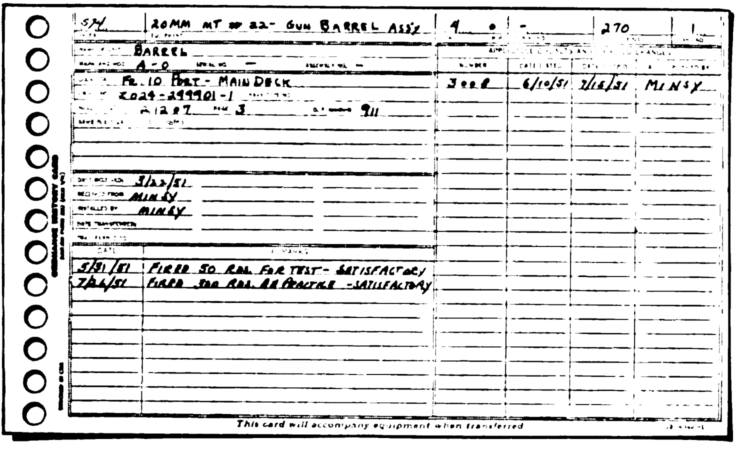
Ballistics Log

The purpose of the ballistics log is to show gun ballistic variables. These are important both for maintenance and for use by the fire control crew. One ballistics log is kept for each battery, and it should record for each gun barrel (identified by serial number), the rounds fired, stargage data, and bore erosion gage data, plus any other data that concern the ballistic performance of any gun in the battery.

ORDNANCE MACHINERY HISTORY

The CSMP and the Ordnance Machinery History are, between them, the most important material records of the gunnery department aboard ship. The gunnery officer is responsible for keeping the Ordnance History complete and up to date, and very likely a major share of the work will be in your hands, as leading Gunner's Mate.

Until not so long ago the way in which the Ordnance History was kept depended on the preferences of the gunnery officer, and its form and even its content varied considerably from one ship to the next. Today, however, there is a standard form and fairly uniform minimum requirements. Of



574 20MM MT # 22- GUN BARREL ASS'Y 4 - 270 1

BARREL

A-0 — —

FR. 10 PORT - MAIN DECK

Z024-299901-1

A1207 3 911

3/22/51

MINSY

MINSY

5/31/51	FIRED 50 RDS. FOR TEST - SATISFACTORY	3008	6/10/51	7/15/51 MINSY
7/26/51	FIRED 300 RDS. AA PRACTICE - SATISFACTORY			

This card will accompany equipment when transferred

Figure 2–13.—Ordnance History Card. (NavOrd Form 2032.)

course, the gunnery officer may find it desirable to maintain additional records as part of the Ordnance Machinery History, but this chapter presents the basic minimum.

The Ordnance History Card (NavOrd Form 2032) is the standard form used in the Ordnance Machinery History. The complete History, made up of these cards, serves also as a complete list of the ordnance equipment aboard the ship. The cards are made out (as illustrated in fig. 2–13) one to each item of equipment, in accordance with instructions in the current BuOrd directive on inventory of ordnance equipment. (At this writing these instructions are in OCL X1–49.)

When you make out the top part of the card, note that you must, to ensure accuracy, obtain EXACT nomenclature and serial numbers DIRECT from the equipment name plates. Don't rely on older inventories, shipping documents, logs, or anything else of the sort. Only in this way can you make your Ordnance History reliable enough to serve as the basis for inventories and reports about the equipment.

What do you enter in the bottom half of the card and on its reverse side (not illustrated)?

That's where the "history" part comes in. Here's a checklist of what these entries should include:

Major repairs
Parts replaced
Material failure
Filling of hydraulic units and type of oil used
OrdAlts
Field changes
Modifications
Equipment hours per quarter
Rounds fired
Stargage data
Bore erosion data

Besides these, enter anything else that you or the gunnery officer may consider necessary to make the record comprehensive and informative. Of course, you will omit routine cleaning, operation, and adjustments. In deciding what to put in, remember that the complete material history of a unit is important in determining inadequacies in material, design, and maintenance or operational practices. With the History as a background, it is possible to recommend design changes, indicate improved methods of operation to decrease or eliminate casualities, or suggest new safety precautions. The History should not only be kept up to date but should be periodically reviewed and analyzed if it is to be of real value.

You obtain material for this "historical" part of the History from the logs and CSMP file.

Ordnance History Cards should be kept on board as long as the equipment itself remains on board, even if the vessel is decommissioned or taken out of service. Only if the ordnance unit it describes is transferred off the ship should the card be removed from the file. The transfer should be recorded in the appropriate space, and the card forwarded with the equipment.

SUMMARY

In this chapter we have taken up the specific types of maintenance work that will be of most concern to you as a GM1 or Chief. Except for the details of turret gun maintenance, which have not been taken up in earlier courses in this series, there has been no attempt to cover in the chapter the actual technical operations involved in the maintenance of the ordnance equipment you will be responsible for.

For those technical details, see the applicable OP's and OML's. Review also the earlier courses in this series on gun and mount maintenance and the other chapters in this book on ammunition, bomb-type ordnance, rockets and projectors, and battery alignment. For further detail on supply, which is closely tied up with maintenance paper work, see chapter 10.

QUIZ

In each of the following, select the BEST answer.

1. As a GM1 or GMC, your CHIEF responsibility with respect to upkeep is

a. lubrication	c. repairs
b. alterations	d. supervision

2. Which of the following routine operations in gun bore maintenance applies to turret guns but not usually to smaller guns?
   a. Decoppering
   b. Checking rifling for evidence of erosion
   c. Checking liners for twist and extension
   d. Bore gaging

3. The function of the liner locking ring is to
   a. prevent liner protrusion to the rear
   b. prevent liner protrusion at the muzzle
   c. lock the breech plug closed
   d. prevent excessive erosion of the liner

4. The prescribed method of measuring liner twist is to
   a. measure the displacement of scribe marks on muzzle and liner
   b. measure the extension of the liner beyond the forward face of the tube
   c. measure the distance from gun breech face to liner rear face
   d. measure the rotation of the breech plug as the breech is closed

5. Which of the following can cause steel constriction?
   a. Excessive wear of the rifling
   b. Excessive use of the lapping head
   c. Extension of the liner
   d. Twist of the liner

6. The stargage is used to measure
   a. bore diameter at selected points
   b. forcing cone extension
   c. rifling groove depth
   d. liner twist

7. The stargage vernier must be set on zero
   a. while the gage points are in the gun bore
   b. while the gage points are in the testing ring
   c. before you read the vernier scale
   d. before the gage is removed from the gun bore

8. The stargaging process includes measurement of the bore at six points. At which of the following points is one measurement made with an instrument OTHER THAN the stargage?

a. The muzzle
b. The origin of the bore
c. Twelve inches from the muzzle
d. Twelve inches forward of the origin of the bore

9. Displacement of the yoke locking ring will cause the
   a. breech mechanism to jam
   b. liner to protrude
   c. trunnions to become unbalanced
   d. gas-check seat to leak

10. The recommended method for lubricating the threads of the plug and the screw-box liner is to
    a. apply oil sparingly with your finger tip to the screw-box liner and plug threads
    b. apply oil liberally with an oil can to the screw-box liner and plug threads
    c. lubricate the plug threads and close the breech
    d. lubricate the screw-box liner and close the breech

11. The carrier holding-down latch is released in order to
    a. admit air to the air closing cylinder
    b. unlock the plug for closing the breech
    c. unlock the plug for opening the breech
    d. rotate the breech operating handle

12. Which of the following is a possible cause of over-fast closing action of the breech plug of a turret gun interrupted-screw breech mechanism?
    a. Translation of the breech plug along its axis of rotation
    b. Primer blowback as the breech closes
    c. Overlubrication of engaging threads
    d. Excessive air pressure to the closing cylinder

13. Excessive counterbalancing spring compression in the breech mechanisms of bag-type turret guns is a direct cause of
    a. misalignment of the plug and screw-box liner
    b. excessive air pressure to the closing cylinder
    c. uncertain holding-down latch functioning
    d. slamming of the breech when closing

14. Which one of the following statements regarding present model salvo latches on turret bag-type guns is NOT true?
    a. The latch can be disengaged manually by a deliberate act.
    b. The latch is disengaged in recoil by inertia.
    c. It is possible to lock the salvo latch out of action.
    d. The salvo latch locks the breech operating handle as soon as the breech is fully closed.

15. A properly functioning gas-ejector system on a bag gun
    a. hastens the clearing of gas from bore and chamber
    b. aids in exhausting dangerous fumes from powder magazines
    c. eliminates the necessity for the "Bore Clear!" signal
    d. eliminates the necessity for inspection of bore and chamber after each round

16. Which one of the following is NOT a component of the gas-check assembly?
    a. Gas-check seat
    b. Gas ejector
    c. Mushroom head and stem
    d. Split rings

17. If, after installation of a new gas-check pad, the breech mechanism is stiff in operation, the best way to limber it up is to
    a. open and close the breech several times
    b. apply chalk to the gas-check seat
    c. increase air pressure to the air closing cylinder
    d. relubricate the engaging threads of the plug

18. In the Mk 14 firing lock, a sprung extractor will
    a. cause a misfire
    b. prevent percussion fire
    c. shear the primer retaining catch
    d. jam the firing lock

19. The term "repair" as applied to naval equipment does NOT include
    a. replacement of parts or assemblies with identical parts
    b. alignment of parts or assemblies with mating units
    c. addition of new parts or assemblies to existing assemblies
    d. work required to restore equipment to serviceable condition

20. Which of the following types of ships would be most likely to have facilities for extensive repair to a 5"/38 twin mount?
    a. AR
    b. AS
    c. ARS
    d. AGP

21. Alterations great enough to modify the military characteristics of a vessel must ALWAYS be authorized by
    a. CNO
    b. BuOrd
    c. BuShips
    d. fleet commander

22. Which of the following is NOT used for keeping records of alterations to ordnance equipment?
    a. CSMP
    b. Battery log
    c. Plates attached to the equipment
    d. Check-off lists

23. Which of the following serves as the main source of information regarding repairs and alterations of ordnance material aboard ship?
    a. A. & I. program
    b. CSMP
    c. Check-off lists
    d. Battery logs

CHAPTER 3

ELECTRICITY FOR THE GUNNER'S MATE

INTRODUCTION

As a First-Class or Chief Gunner's Mate you're expected to know enough about electricity to test electric circuits in your gun mounts, and to make certain types of adjustments, repairs, and replacements of electrical gear. You've been making firing circuit tests since you were in third class; now you're also going to be able to check power circuits, locate and replace fuses, zero synchros, check electronic amplifier inputs and outputs, wire and test demolition circuits, make certain depth charge electrical tests, and perform other maintenance jobs on electrical equipment.

Now this doesn't mean that you're going to replace the Electrician's Mate, Electronics Technician, or Fire Control Technician; it does mean that you'll do testing, replacement of defective unit assemblies, and a certain amount of adjustment. For example, if your 5-inch mount's rammer power motor burns out its stator winding, or if a 40 mm mount's amplifier has a defective filter condenser, you're not going to be expected either to rewind the stator or to find, remove, and replace the condenser. You will replace the entire motor or the entire amplifier. There is one kind of individual electronic component (as distinguished from complete assemblies like amplifiers) that you may be expected to remove and install without calling on qualified electronics experts—namely, electronic tubes.

Now, what will you have to know to tackle this part of your job?

You should know the operating principles of all the electrical equipment that you will deal with, and you should know how to test the circuits and devices you are responsible for. That is what this chapter is intended to help you learn.

As a preliminary, before you begin to study this chapter, you should reread the basic Navy training course *Basic Electricity* (NavPers 10086). In general, although this chapter will very briefly review the subject matter of that course, the review is intended only as a refresher or transition from the basic course to this one. It's assumed here that you have already studied *Basic Electricity* and require little groundwork aside from such a review.

ELECTRICITY REVIEW

And now let's begin the review by taking up the characteristics of current electricity.

Characteristics of Current Electricity

At the outset, we must distinguish between CURRENT (that is, flowing) electricity and the STATIC (that is, standing or stationary) variety. In this chapter we are concerned with current electricity only.

By now it's become pretty trite to say that though we know a great deal about what electricity does, we still don't know what it is. This statement doesn't mean much—and hasn't for many years. The fact is that electricity, as you deal with it, is mathematically predictable stuff, with no mystery or irrationality about it.

We know that electric currents flow relatively easily through substances (usually metals) called CONDUCTORS, and not very well through others (for instance, rubber or Bakelite) called INSULATORS. With few exceptions (and those only at temperatures that you need not expect to encounter) all conductors, even the best, offer a certain amount of RESISTANCE to the flow of electric currents; and there are conditions under which even the best insulators will permit the flow of current. In that connection, you should always remember, when you deal with any electrical gear, that a WET or even a moist insulator isn't much of an insulator if water—especially salt water—provides a path for leakage of current.

We measure electricity with an exact and rather ingenious system of units. They're easy to understand if, for the moment, you think of electricity as something like a liquid flowing in a pipe. The unit of rate of flow of electric current is the AMPERE, just as "gallons per minute" expresses the rate of flow of a liquid in a pipe. The electrical pressure that forces the current through a conductor is measured in VOLTS, just as we may measure the head or liquid pressure in a pipe in pounds per square inch.

In hydraulics, we have no special unit to measure RESISTANCE to flow, but in electricity we do—the OHM. A conductor whose resistance is such that a pressure of 1 volt establishes a current flow of 1 ampere has, by definition, a resistance of 1 ohm. This can be put into mathematical form:

$$\text{Resistance}=\frac{\text{Voltage}}{\text{Current}}$$

which you should instantly recognize as a statement of Ohm's law. The conventional symbols for voltage, current, and resistance, are respectively E, I, and R, and you know that Ohm's famous law can be stated in terms of these symbols in any of three ways:

$$I=\frac{E}{R}$$

$$R=\frac{E}{I}$$

$$E=IR$$

The second of the three corresponds to the form in which it was expressed, using words instead of symbols, in the preceding paragraph.

We measure electrical power in WATTS, and in the situation we have described, when 1 volt forces 1 ampere through 1 ohm, the power consumed is 1 watt. There are 746 watts to the horsepower. You can calculate the power in watts delivered to any direct current circuit by multiplying the current input by the applied voltage ($P=EI$).

An electric current flowing in one direction only, like hydraulic fluid in most of the hydraulic devices you know, is DIRECT CURRENT (DC). Direct current may be perfectly steady, or it may PULSATE or fluctuate regularly while flowing always in one direction. Or the current and voltage may change direction regularly; this is ALTERNATING CURRENT (AC).

Electricity may manifest itself by producing heat, magnetic effects, chemical effects, and electrostatic-field effects. All of these are important in electrical equipment, and all are either used or so far as possible prevented, depending on the use and characteristics of the equipment.

You're familiar with the fact that the passage of current through a conductor produces heat. The commonest application of this phenomenon happens to be the commonest electrical device there is—the incandescent lamp, in which the heat produced is great enough to keep a metal conductor called a filament literally white-hot. The same principle is applied in electric primers, where a hot filament lights off a bit of guncotton to set off the remainder of the explosive train in the propelling charge.

Though electric currents produce heat, the effect is pretty much irreversible: heat will not directly produce electricity—at least not on a scale practical for production of power—by any process now known. (Tiny electric currents produced by THERMOCOUPLES exposed to heat can be used, for example, to indicate temperatures.)

However, this is not true of the MAGNETIC effects of electricity. Current flow produces a magnetic field, and a magnetic field can produce current flow—provided that the field cuts across the conductor or the conductor cuts across the field. That doesn't mean that there must be physical movement—though physical movement will suffice; if the magnetic field expands, or contracts, or rotates, or is displaced in such a way that it cuts across the conductor it will produce a voltage in the conductor by INDUCTION.

The chemical effects of electricity can likewise be reversible. We will not go into the chemistry of batteries, but you have the elements of a battery whenever you have two dissimilar metals in an ELECTROLYTE (which we will for the purpose of this chapter define only as a water solution that will conduct electricity). You can read up on the principles and characteristics of batteries in the Navy basic course in *Basic Electricity*, but you should bear this particular point in mind. One reason is that this effect is responsible for the corrosion that appears whenever sea water has constant access to places where one metal contacts another. Another is that one type of mine utilizes this effect to set it off on contact with a ship's hull.

The electrostatic-field effects of electricity are utilized in capacitors, and have a good deal to do with the design of high-frequency radio and radar gear and transmission lines, but since you won't have much to do with them directly, we shall not take them up here.

Circuits

Next in our review, let's briefly consider the aspects of electricity that we wrap up in the word CIRCUITS.

First of all, SYMBOLS. These are the signs that we use in plans of electrical circuits to stand for the electrical devices in the circuit. There's a pageful of them in *Basic Electricity* (NavPers 10622–B), and several pages full in *Blueprint Reading and Sketching* (NavPers 10077–A). You will find still more sets of electrical symbols in standard textbooks on drafting and in Navy training courses for Electrician's Mate, Fire Controlman or Fire Control Technician, and other rates that are concerned to any great extent with maintenance of electrical or electronic gear.

All these sets of symbols are good, and any of them can be used for reference if you want to draw a sketch or interpret a blueprint. But you have no doubt noticed that on different drawings the electrical symbols vary a good deal from one drawing to the next, and you will notice, if you care to investigate, that many of the symbols published in the books mentioned above differ from one book to the next.

One reason for this is the human variability to which everybody is subject. Maybe you make a dollar sign with two vertical strokes; others use just one stroke, but you still recognize the dollar sign. Or sometimes one symbol for, let us say, a synchro, shows certain internal features that are important to the understanding of the circuit, but the same symbol is too elaborate in another context where these features either are understood or are not important. You'll see an example of this in figure 3–10 later in this chapter.

You will also have to watch for certain CONVENTIONS in schematic drawings of electrical circuits. Consider current flow, for example. Formerly, we used to assume current flow in the direction OPPOSITE to electron flow. But the latest convention is to assume direction flow in the same direction as electron flow. (This is explained in *Electricity.*)

Another convention is how to show connections between conductors. In some drawings (as in fig. 3–1, A), you will find that connections are shown merely by crossing or joining the conductors concerned, while conductors that cross without being connected are depicted with a little "bridge" to indicate nonconnection. But another convention (fig. 3–1, B) requires the connection of conductors to be shown by a black dot, while conductors that cross without being connected are depicted by two lines crossing, without any "bridge" or other distinctive marking. So two lines crossing can mean either a connection or no connection, depending on which convention is used in the drawing you are using. You can tell pretty quickly by inspecting the entire drawing which convention is used; the important thing is not to jump at conclusions.

One other point to bear in mind when you use electrical schematics is that all symbols, whatever their individual variations from those you have first learned, are really simplified sketches—cartoons, in a way—of the equipment they stand for. When you are reasonably familiar with the electrical devices that go to make up the equipment, you will have no trouble in identifying their symbols, even if they are new to you. This, too, is illustrated by figure 3–10.

There are, you know, two general ways of arranging electrical components in a circuit—in SERIES or in PARALLEL, or in some combination of the two. Even complex polyphase

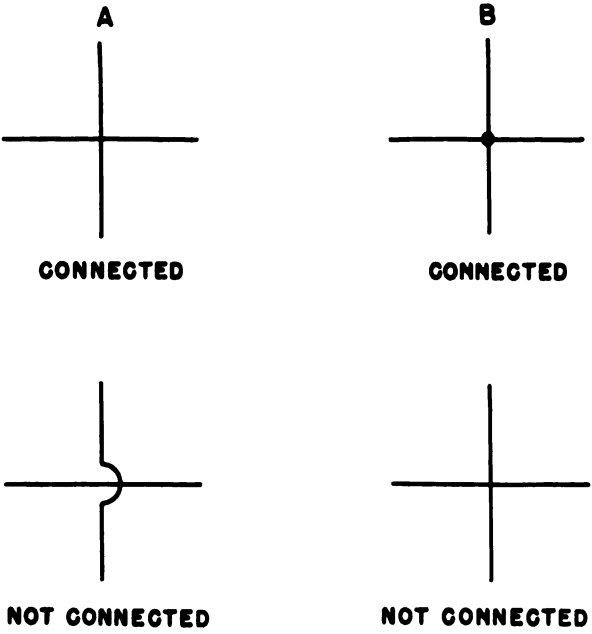


Figure 3–1.—Two conventional methods of showing connections.

AC networks can be reduced to these two fundamental kinds of arrangement. You remember that in series circuits the same current that goes through any one part of the circuit goes through all the other parts. And the amount of voltage drop across any component in the circuit is proportional to the resistance of that component. With parallel circuits, the voltage drop across all the paralleled components is the same, but the current through each component is inversely proportional to its resistance.

None of this should be new to you. If it is, brush up by studying *Electricity*. It will be helpful to work the Ohm's law problems in that course in which you solve for currents and voltages in networks.

DC and AC

The electrical devices you work with operate on either DC or AC. Some will function just as well on one as on the other. Such devices usually depend on the heating effect of the current. For example, the electric primer filament in a 5"/38 propelling charge can be energized either by the output of the firing transformer (and all transformers are AC devices) or (in emergency) by a storage battery (and all batteries are DC devices). But most electrical devices will function properly only on AC or DC of the characteristics for which they were designed.

Let's briefly summarize the characteristics of DC and AC. (Again, use this section only as a checklist of what you should know. If you need further explanation, go back to the basic course in *Electricity*.)

Ohm's law applies in all DC circuits in exactly the form we have quoted it above. There is but one kind of exception—DC machinery in which magnetic fields introduce other voltages, which either add to or subtract from the applied noltages. In such cases the actual voltage is the algebraic difference between the applied and the induced voltages. The best examples of this come up in connection with the COUNTER-EMF in DC motors, and the induced voltages in DC generators.

In AC circuits, Ohm's law usually cannot be applied in the simple form we have mentioned because it doesn't take into account the capacitive and inductive effects of alternating current circuits. These effects in most AC circuits cause the applied voltage to be OUT OF PHASE with the circuit current. The circuit possesses INDUCTANCE (where the phase-shift is caused by the action of magnetic fields) or CAPACITANCE (where it is caused by the action of electric fields).

The effects of resistance, inductance, and capacitance, which can be lumped together under the name of IMPEDANCE, are all similar in that individually they oppose the flow of current.

Resistance increases with the length of a conductor and varies inversely with its cross section. In most devices it varies with the temperature and in all circuits dissipates electrical energy in the form of heat.

Either inductance or capacitance can individually reduce the amount of current, but their effects are opposite. Inductance causes the current to LAG the applied voltage. Capacitance causes it to LEAD the applied voltage. Inductance is the property of a COILED wire and varies directly as the square of the number of turns in the coil. Capacitance exists when the circuit develops an electric field. You can think of both inductance and capacitance as reservoirs which alternately receive energy from a source, then return it. Inductance gives the current an inertia-like quality. Capacitance gives it an elastic quality.

The mathematical expressions of Ohm's law in AC circuits containing inductance and capacitance are much more complicated than those that you studied earlier in this chapter.

With this high-speed review, let us leave the more theoretical aspects of electricity and take up in some detail specific circuits and devices with which you are expected to be familiar.

FIRING AND LIGHTING CIRCUITS

You find firing and lighting circuits on all naval gun mounts from 3"/50 up. The circuits in figure 3–2 are typical; they do not represent exactly the circuits for any specific gun mount (though they closely resemble the common 5-inch installation), but they show in simplified form what you will find in such circuits.

Take the firing circuit first, and begin with the propelling charge in the chamber. One end of the bridge wire in the primer is connected to the primer case, which makes contact with ground through the metal of the gun. The other end is connected to the primer plunger through the plunger cup. Contact between the plunger and the external wiring is made by the firing pin in the firing mechanism.

Firing mechanisms are generally equipped with a safety contact, so that the firing circuit is automatically held open until the breech is fully closed and locked. In 5-inch guns this is done by retracting the firing pin until the plug is fully closed. This prevents premature firing. The circuit then passes through the POINTER'S FIRING KEY, which must be closed before the primer will fire.

The firing key is connected to the FIRING SNAP SWITCH mounted near the pointer. This switch has two positions, usually marked BATTERY and MOTOR-GENERATOR. When the snap switch is set on BATTERY, one end of the circuit from the primer is connected to one side of a storage battery. The circuit is completed from the grounded side of the battery. If the safety contact is closed, electric current can pass through the primer when the pointer presses his key.

If the snap switch is set on MOTOR-GENERATOR, the current is supplied from the secondary of the FIRING TRANSFORMER, ground again being used to complete the circuit.

The voltage from the ship's available supply is usually 115, but safety requirements necessitate a lower firing voltage. Hence, a transformer is used to change the voltage. As you remember, a transformer consists of two separate coils of wire wound on an iron core. The coil connected to the source of power is the PRIMARY; the side which delivers the power to the firing circuit is the SECONDARY.

The power normally comes to the firing transformer through a REMOTE FIRING KEY. This key can be used to fire the gun, for unless it is closed no current will flow in the firing transformer or in the firing circuit. But this key will not fire the gun unless the other breaks in the firing circuit are closed first. You are already familiar with how the remote key is used.

Firing circuits require the same careful attention as all other electrical wiring. The flexible leads required to carry the current to recoiling parts must be carefully checked for adequate length to prevent binding and chafing of insulation, as well as for loose connections. Insulation must be protected from oil, grease, and moisture. The Bureau of Ordnance prescribes various tests of firing circuits; the surest check of all is the firing of a test primer. (This procedure is described in volume 3 of the Navy training course for Gunner's Mate Third Class.)

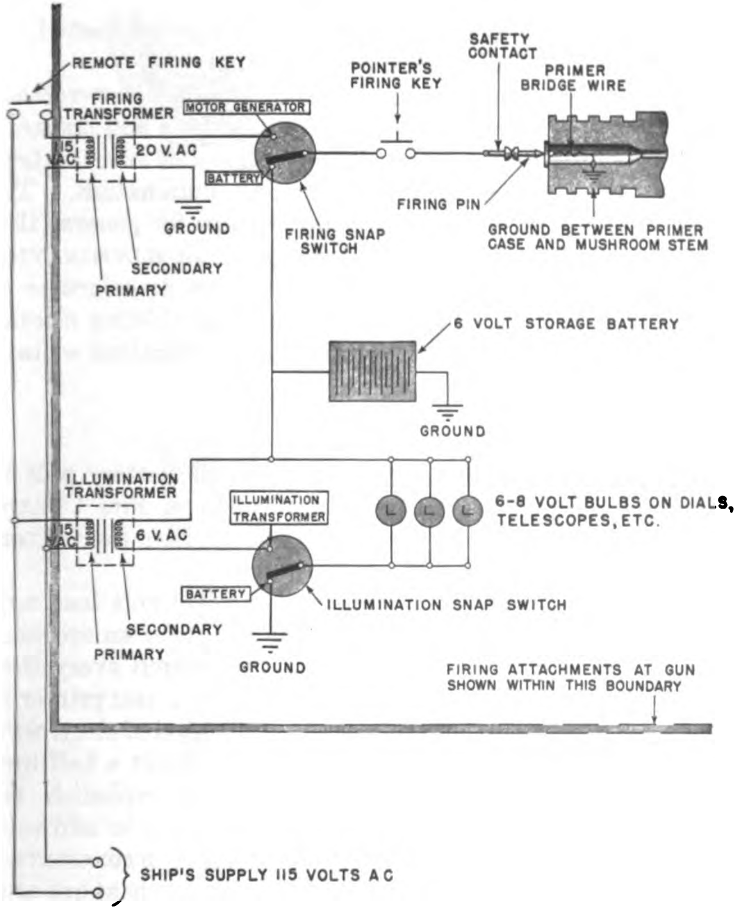


Figure 3-2.—Typical firing and lighting circuits.

You have probably noted that in many mounts one of the two firing switch positions is, as in figure 3–2, labeled MOTOR-GENERATOR. The explanation is that many older naval vessels are equipped with 115-volt DC electrical systems. This voltage is too high for the firing circuit. Since the firing transformer will not function on DC, and most of the other electrical equipment on present mounts requires AC to function, a motor-generator set is used to produce AC for the mount. The switch often is labeled thus even though the transformer is directly connected, as shown in the figure, to the ship's AC supply.

The lighting circuit is used to supply small low-voltage lamps which illuminate the reticles in pointer's and trainer's telescopes, the dials at the sight setter's and fuze setter's stations, and other dials that require illumination. The lighting circuit is not used to supply lamps for general illumination in the mount. The lighting circuit ILLUMINATION SNAP SWITCH selects either the illumination transformer or the storage battery which also supplies the lighting circuit. Like the firing circuit, the lighting circuit functions equally well on AC or DC.

Batteries

Ordinarily, the firing and lighting circuit battery will be maintained by an Electrician's Mate or by a Fire Control Technician. However, you should know where the battery is and how to check and maintain it.

Since the battery is commonly a 3-cell 6-volt lead-acid type, its maintenance closely resembles that for an ordinary automotive battery. You should test its output every time you check the firing circuit, by using it to fire a test primer or to energize a test lamp or voltmeter. The level of electrolyte should be checked every week; it should be about a half inch above the plates. Use DISTILLED water to replenish the electrolyte. NEVER use sea water, and never try to add acid.

To check the battery's electrolyte, use a HYDROMETER. This is a large glass tube with a long rubber nozzle at one end, a rubber bulb at the other, and a small calibrated glass float inside. (Fig. 3-3.) The idea is to pick up enough electrolyte with the rubber bulb to fill the tube about half-way. The little calibrated float will, as its name indicates, float in the electrolyte, and you read the calibration at its "waterline." This gives you the SPECIFIC GRAVITY of the electrolyte—that is, how many times heavier it is than water.

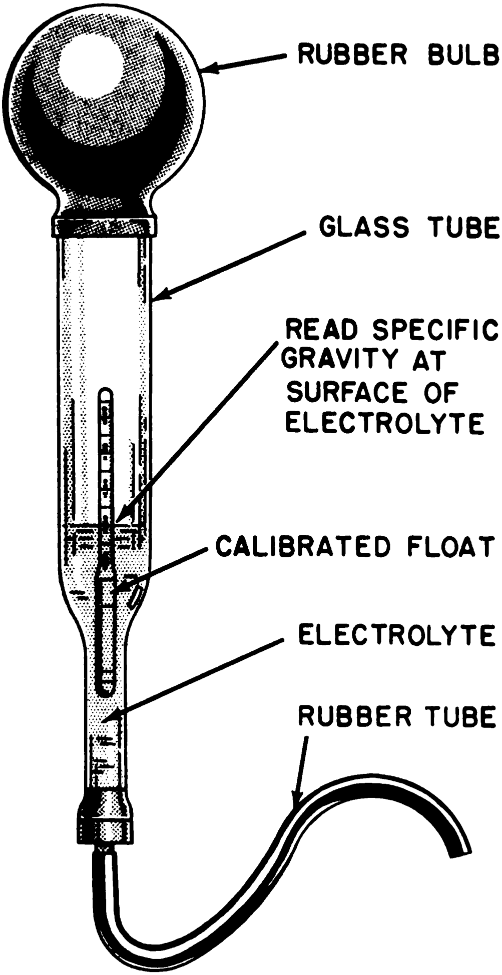


Figure 3-3.—Hydrometer.

As you know, the electrolyte of the lead-acid type of battery is composed of SULFURIC ACID and water. As the battery discharges, the proportion of acid in the electrolyte decreases. Since the pure acid is 1.835 times as heavy as water, it is clear that the electrolyte of a fully charged cell, which contains the maximum proportion of acid, is heavier than that of a fully discharged cell, which contains much less acid. A fully charged cell will give a hydrometer reading of 1.300. A fully discharged cell will read about 1.170. (These figures neglect temperature corrections.)

NOTE: Batteries become discharged even if they are not used. So perform the weekly check whether the firing and lighting battery circuits have been used or not.

Protect batteries, so far as possible, against extremes of temperatures. Low temperatures are very hard on partly discharged batteries. Keep them fully charged, especially if they are in exposed locations.

When you use the hydrometer, test each cell in turn, separately, returning the electrolyte to the cell from which it came. Don't try to take electrolyte from one cell to replenish another. After the cells have been inspected and tested, make sure the caps have been screwed back on tightly.

The only way to restore a storage battery is to RECHARGE it. Adding acid will increase the hydrometer reading, but it won't make the battery capable of renewed output.

Normally, only the water in the electrolyte is lost by evaporation. The battery can lose acid only if there is a leak in the case.

Leave to the expert (namely, the Electrician's Mate) the business of recharging the battery, of replacing it when it is worn out, or of changing the electrolyte.

One other point about battery maintenance: Use thick grease or petroleum jelly on the battery terminals and connecting bars to keep them free of corrosion. Apply the grease after the battery has been installed and connected. The coating should be renewed when necessary.

These instructions apply to lead-acid batteries only. If you have Edison cells in your mounts, they call for different maintenance procedures. See the Electrician's Mate.

ELECTRICAL MEASURING INSTRUMENTS

As you remember from *Basic Electricity*, instruments for measuring electricity can be made according to a number of different principles—and that basic course by no means exhausts the principles used in such instruments today. You, however, will be concerned with instruments of one type of construction only—the D'ARSONVAL meter. Figure 3–4, *A*, shows the d'Arsonval movement with one magnet pole piece partially removed to reveal the heart of the movement; the smaller diagram (fig. 3–4, *B*) indicates how both pole pieces surround the stationary iron core.

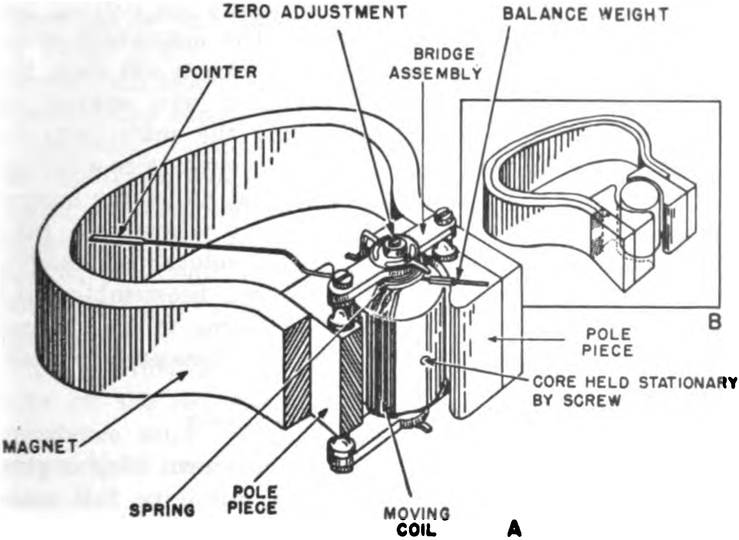


Figure 3–4.—D'Arsonval meter movement.

The d'Arsonval meter movement is like a fly-power motor with a lightweight armature (fine copper wire coil wound on a thin aluminum frame), heavy permanent magnet field, and light spiral springs which conduct the current to the moving coil (thus taking the place of commutator or slip rings), and restrain its movement. Its moving parts are made as nearly frictionless as possible; its bearings are jewels like those in a watch. The cylindrical iron core which the moving coil assembly encloses is not part of the "armature"; it is secured in place by a screw, and the moving coil moves in the tiny gap between it and the magnet pole pieces. The pointer is counterbalanced by three little adjustable weights (which you must never attempt to adjust), of which one is pointed out in the figure. The little screw labeled ZERO ADJUSTMENT is accessible at the face of the assembled instrument, and is used to adjust the springs so that the pointer is exactly at zero when the instrument is not energized.

As you can see, the d'Arsonval movement is built like a watch—and deserves the care you would give a fine watch. Never jar the instrument—you may throw the moving coil assembly out of its jewel bearings. The instrument must never be overloaded, or the excessive torque will slam the lightly constructed moving coil assembly over against its stops, bending the needle, dislocating the shaft from its bearings, or even burning out the light copper wire winding. Lastly, don't try to repair any electrical measuring instrument by yourself. Except for the zero adjustment (and even that shouldn't be touched unless absolutely necessary), there are no adjustments possible without disassembling the instrument at least to the extent of taking the face panel off, and you should never attempt ANY disassembly at all.

Voltmeter and Ammeter Circuits

As you may know, the d'Arsonval movement itself is very sensitive, and in many instruments will give full scale deflection on 1 milliampere (0.001 ampere). At least one instrument that the Navy issues as standard testing equipment gives full scale deflection on 50 microamperes or 50 millionths of an ampere (0.000050 ampere) DC. But the currents you will measure may be as great as several amperes. Moreover, such an instrument will deflect full scale at 50 millivolts (0.050 volt), and that's way below the voltages you will usually be measuring.

The way to adapt a sensitive meter to service as a voltmeter or ammeter in more practical ranges is to introduce a MULTIPLIER resistance in series with it (to measure voltage), or to put a by-pass or SHUNT across it (to measure current). For example, suppose you have a milliameter that deflects full-scale at 10 milliamperes (abbreviated MA), or 0.01 ampere. Let us say that the actual resistance of the moving coil assembly is 5 ohms. To change it to a voltmeter with a full-scale rating of 150 volts all you have to do is connect in series with it enough additional resistance to bring the total to:

$$R=\frac{E}{I}=\frac{150}{0.01}=15{,}000 \text{ ohms.} \qquad \text{(Fig. 3–5, } A.)$$

Since the meter's resistance is 5 ohms, you add a resistance of 14,995 ohms. By Ohm's law, you can see that if you connect the meter, thus modified, across a 150-volt supply, the resulting current will be 10 milliamperes.

Similarly, by substituting other resistances (whose values can be determined easily by applying Ohm's law), you can make one meter serve for a number of different voltage ranges. Or you can use one resistor, tapped at various points. The only other modification necessary will be to substitute new scales calibrated for the ranges you are measuring.

To get this same meter to measure higher current, you take off the resistors and put across its terminals a low-resistance shunt. (Fig. 3–5, *B.*) For currents up to 10 amperes, for example, you use a shunt of:

$$R=\frac{E}{I}=\frac{0.050}{10}=0.005 \text{ ohms resistance.}$$

With this setup, only one one-thousandth of the current goes through the 5 ohms of the meter's moving coil; 999 one-thousandths of the current goes through the low-resistance shunt. By using a shunt of one-tenth of even this low resistance, you can measure currents ten times larger—up to 100

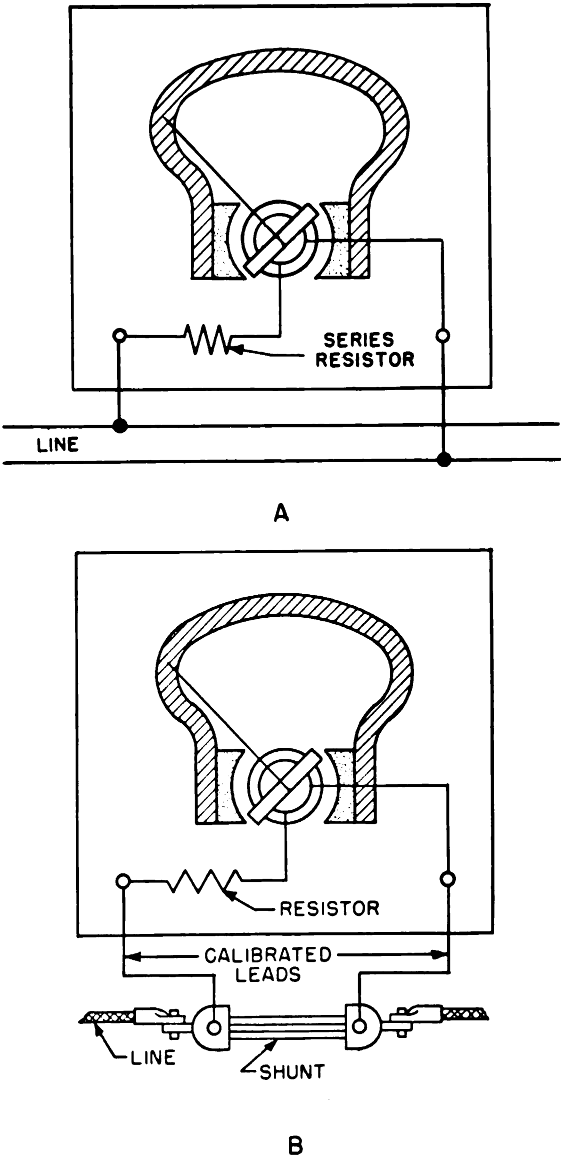


Figure 3–5.—Voltmeter and ammeter connections. A. Voltmeter. B. Ammeter.

amperes. With several shunts to switch in, and extra scales printed on the meter face, you have the equivalent of several ammeters.

In this way you can use one high-quality sensitive d'Arsonval meter to serve as the equivalent of several ammeters and voltmeters. All you need, besides the meter, is a number of accurate resistors and shunts, and switching arrangements so that you can set the whole apparatus up easily and quickly to measure the currents and voltages you're interested in.

But this isn't all. Remember that many, if not most, of your measurements will be on AC rather than DC. What to do?

Answer: Insert a RECTIFIER. Most instrument rectifiers consist of alternate copper and copper-oxide plates. Current passes from the copper to the oxide, but not the other way. By connecting four such units in a "bridge" circuit, with the meter across the bridge, current passes through the meter in the same direction regardless of the regular changes in polarity of the AC input. (The bridge circuit is beyond the scope of this course. You can find an explanation of it in *Basic Electricity*, NavPers 10086.) There is some sacrifice in the d'Arsonval instrument's accuracy when it works on rectified AC, though not very much.

Otherwise, voltmeter and ammeter connections, using the d'Arsonval movement, are the same for AC as for DC. However, DC scales cannot be used for AC measurements, because of the different characteristics introduced by use of the copper oxide rectifier.

Resistance Measurement

The d'Arsonval movement can be hooked up also to measure RESISTANCE. In the commonest application of this kind of circuit, shown in figure 3-6, the meter gives full scale deflection (for zero resistance) when you touch the test prods together. Then, any resistance introduced between the test prods reduces the deflection. The greater the resistance, the greater the reduction in deflection. Therefore, the ohm scale reads BACKWARD—from right to left—and is so calibrated.

The SERIES RESISTOR is used to reduce the current to a safe value. The current source is a battery right inside the ohmmeter itself. Dry cells are usually used. Since their output voltage varies with age and use, you zero the ohmmeter by resetting the ADJUSTING RESISTOR.

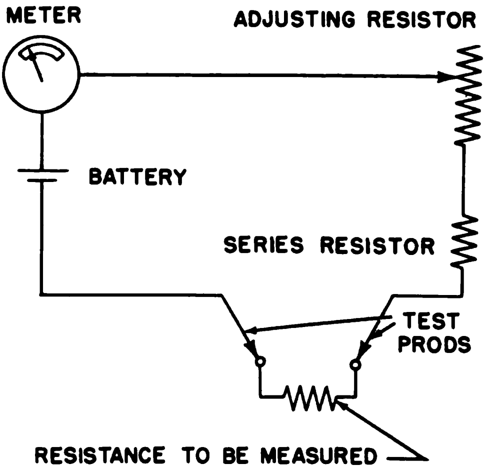


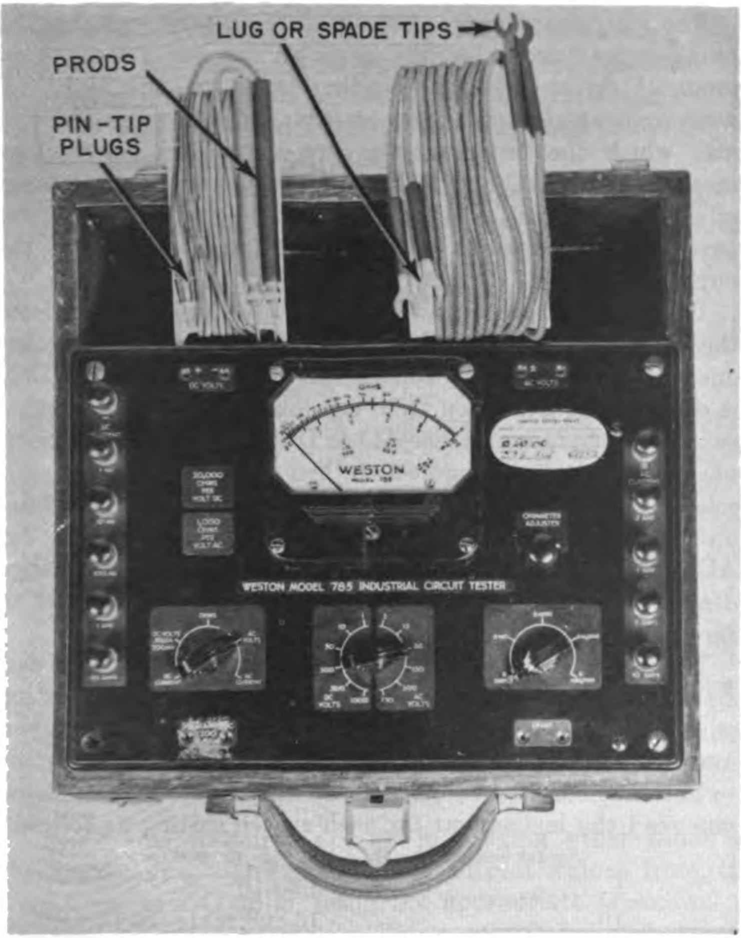
Figure 3-6.—Ohmmeter circuit.

Warning: The ohmmeter can be used safely only when the circuit or unit being measured is FULLY DEENERGIZED.

Weston Industrial Circuit Tester (Multimeter)

Now let's look at one of the combination voltmeter-ammeter-resistance meter-AC-DC instruments that the Navy uses. The one we'll take up here is a commercial job (they all are at the present time) manufactured by Weston Electrical Instrument Co. as their model 785, and illustrated in figure 3-7.

This instrument consists of a large d'Arsonval type meter set in a bakelite panel, and housed in a sturdy wooden box with carrying handle and hinged cover (not shown). Inside the cover is an instruction sheet with detailed information



Courtesy of Weston Electrical Instrument Co.

Figure 3-7.—Weston industrial circuit tester model 785.

on using the instrument. In a compartment above the meter is a pair of test lines, with pin-tip plugs at one end and prods at the other; and a pair of connecting wires with spade terminals at both ends for attachment to binding posts. The prods are used for voltage and resistance measurements; the connecting wires with spade ends are used for current measurements.

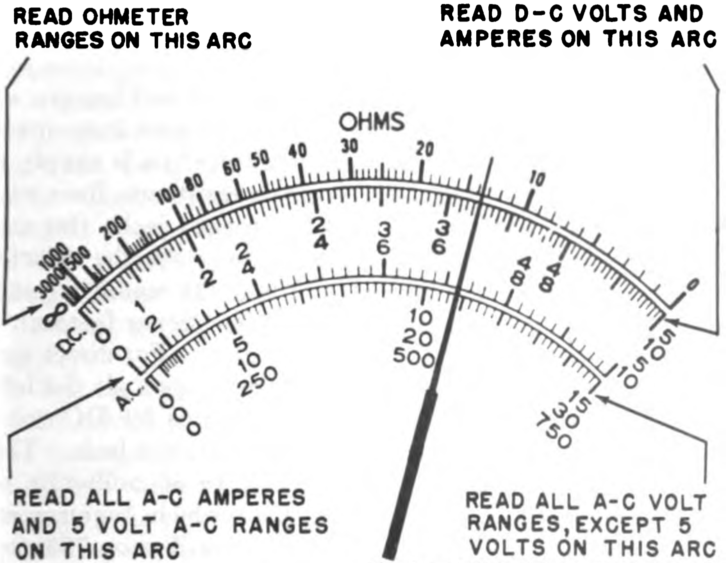
The instrument panel contains three rotary switches, an ohmmeter adjuster, binding posts on the left for measurement of direct currents, binding posts on the right for measurement of alternating currents, and four pairs of jacks, into which the test line plugs fit—two pairs for voltage measurements (AC and DC respectively), one for resistance measurements, and one for direct connection of the meter (without the networks of multipliers and shunts) to the outside.

The rotary switch on the left (FUNCTIONAL SWITCH) selects the instrument function desired—voltage, current, or resistance measurement. If voltage measurement (AC or DC) is desired, the next step is to set the center rotary selector switch for the range (either AC or DC) desired. For current measurement (in a range other than 50 microamperes), you select range by choosing the appropriate binding posts (those on the left of the instrument for DC, those on the right for AC). For resistance measurement, you select the range desired with the rotary selector on the right and adjust to zero with the ohmmeter adjuster knob.

The scales on the instrument reflect its multipurpose use. Be careful to use the proper scale and the proper calibration on each scale, as shown in figure 3–8. For some ranges you multiply or divide the indicated reading by the proper factor to obtain the actual value. If you are measuring DC volts, you read the instrument for each switch setting as follows:

Switch setting (volts)	*Scale and factor*
1	10÷10
10	10 full scale (no factor)
50	5×10
200	10×20
500	5×100
1,000	10×100

Of course, you use the scale marked DC, which has 100 calibration lines. You read the indication (using either the 0–5 or 0–10 numerical markings, as required) and multiply or divide by the factor shown. Let's assume that the test prods are plugged into the DC volts jack, and the center range selector switch is set at 50 on its left-hand scale. With the meter indicating as shown in figure 3–8, you read the indication on the basis of full scale deflection being 5 (0–5 scale). The indication is 3.25 on this scale, and you multiply it by 10 to get the actual voltage—32.5.



READ OHMETER RANGES ON THIS ARC

READ D-C VOLTS AND AMPERES ON THIS ARC

READ ALL A-C AMPERES AND 5 VOLT A-C RANGES ON THIS ARC

READ ALL A-C VOLT RANGES, EXCEPT 5 VOLTS ON THIS ARC

Courtesy of Weston Electrical Instrument Co.

Figure 3–8.—Scales of meter of model 785 circuit tester.

The same principle applies in making other kinds of measurements. You read direct current values from the same arc as DC volts, using the appropriate factors of 10 applied to the 0–10 scale. You read AC volts above the 5-volt range from the bottom arc, selecting scales and multiplying (when necessary) as follows:

Switch setting (volts)	*Scale used*
5	5 full scale
15	15 full scale
30	30 full scale
150	15×10
300	30×10
750	750 full scale

Use the arc just above this one for AC volts in the 5-volt range, and for AC amperes, using the 0–5 or 0–10 scales as appropriate. For resistance, you read ohms off the top scale, from zero (0) on the RIGHT to "INFINITE" (∞) resistance on the left. Remember that this scale runs backwards as compared to the others. Use multiples of 10 as factors in resistance measurements, as indicated by the range selector switch on the right.

After you make a few measurements, you will become accustomed to using and reading this multipurpose instrument. For most of these measurements, the procedure is simply to connect the leads (prods for voltage or resistance, lines with spade terminals for current) to the proper jacks (for test prods) or binding posts (for spade tips), set the selector switches for the ranges desired, and take the readings (reading from the proper scales and using the proper factors).

There is one exception to this procedure. For direct current measurements up to 50 microamperes, you set the left-hand selector switch to the same position as for DC volts. And you plug the pin tips in the lower left-hand jack. This procedure is used also for measuring up to 50 millivolts, or for measuring DC over 10 amperes, which requires an external shunt. (The biggest shunt in the Weston 785 goes up only to 10 amperes.) There are few occasions for you to be measuring currents and voltages in these ranges. If it becomes necessary to do so, call in a First-Class or Chief Electrician's Mate or Fire Control Technician for expert assistance.

Here are some pointers on using this and similar instruments:

1. Test leads are usually color coded for proper polarity on DC. In the Weston 785, for instance, you should plug the black pin tip into the jack marked negative, and the red tip into the jack marked positive. Otherwise the meter pointer will merely push against the zero stop.

2. Scales are also color coded. In model 785, the AC scales are all in red.

3. When making either voltage or current measurements where you are not certain of the range to use, start with the HIGHEST range and work down. These instruments are expensive, and you want to be careful to avoid damaging them or burning them out.

4. Before taking any resistance measurements, be sure the device you are testing is COMPLETELY deenergized. If it contains large capacitors, as many electronic devices such as power amplifiers do, these will have to be discharged separately, since they can produce destructive current surges even when the device has been disconnected from its power source. Under these latter circumstances, be sure to have an expert around for assistance. However, you won't have this kind of trouble with firing and lighting circuits, interlocking circuits, and the like, nor will you have this trouble in measuring inputs and outputs of receiver-regulator amplifiers.

5. For the reason mentioned in the preceding paragraph, and for others equally good, DON'T pry into the chassis or other innards of ANY electronic devices.

6. When measuring high voltages, use ONE hand only. Never give the current a chance to pass through your body—especially your heart. By the way, even low voltages are dangerous if the place you're working in is shipping water, or you're wet, even if only with your own perspiration.

7. Before actually permitting current to flow into the instrument, check always to be sure that you've set it up for a safe range, and for the proper function. If you're set for taking current measurements, be sure the instrument is NOT connected ACROSS the line, or you'll burn it up for sure. It isn't actually unsafe to have the instrument in the line when set up for voltage measurement, but it won't get you anywhere.

The Megger

The MEGGER is a special instrument for measuring resistance. You'll use it especially for testing the insulation in firing circuits. It's more than just a meter—it contains a small DC generator and a sensitive voltmeter. The generator has a permanent magnet field and its armature is turned by a handcrank mounted on the side of the megger case. (Fig. 3–9.) The moving-coil indicator and the armature of the megger share the same field magnet structure.

One advantage of the megger over the conventional ohmmeter is that its generator produces a HIGH voltage (from 100 to 1,000 volts). And it will measure a much higher resistance than the ohmmeter. In fact, the megger's name comes from the units on its scale—MEGOHMS—millions of ohms.

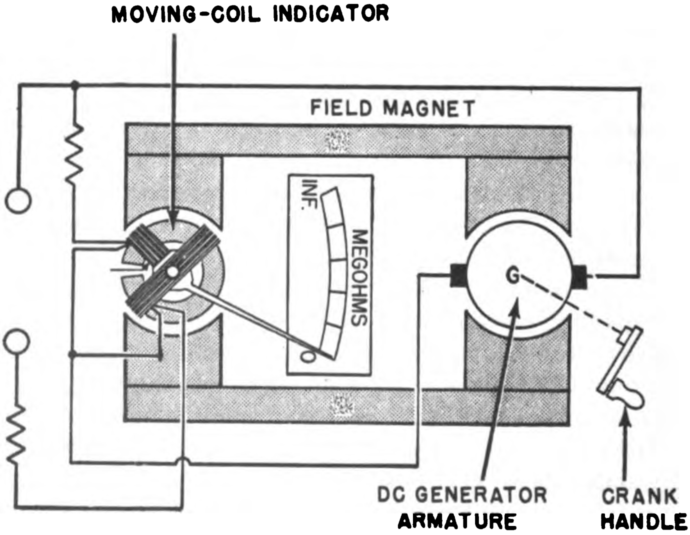


Figure 3–9.—The megger (schematic).

So much for electrical measuring instruments. The characteristics and methods of use of any particular model will, of course, vary from those of the instruments we have taken up above. But if you remember the principles on which these instruments function, and make good use of the instructions supplied with them, you won't go wrong.

Now let us go on to another electrical device that you're expected to be able to work with—the SYNCHRO.

The device illustrated in figure 3–10 is called different names by different manufacturers. General Electric calls it a "Selsyn," Kollsman calls it a "Teletorque," and to Bendix it's an "Autosyn." In the Navy, regardless of its manufacturer, it's called a SYNCHRO.

In previous courses, you learned that there are two kinds of synchro—the TRANSMITTER and the RECEIVER— and that the insides of the two consist of a rotating part (ROTOR) and a stationary part (STATOR). You learned that any two synchros must be connected by five wires of which three are to the stator and two to brushes which contact slip rings on the rotor. You also learned that when a synchro system is energized at any position of the rotor with respect to the stator the transmitter output is such as to drive the receiver rotor to the corresponding position. And you learned how the synchro receiver is used in zero reader dials, follow-the-pointer dials, and servo mechanisms.

Now let's go into a little more detail about synchros.

Figure 3–10, *A* illustrates a cut-away view of a synchro TRANSMITTER. A synchro receiver is similar except for one constructional feature that will be explained later in this section. Parts *B*, *C*, and *D* show three common ways of depicting the synchro in schematics. Part *C* is best for our purposes because it is easy to trace through each circuit. The stator doesn't actually LOOK like the diagram in the schematic, but don't let that bother you. S1, S2, and S3 are the stator connections, and R1 and R2 are the rotor connections.

These schematics apply equally well to the synchro RECEIVER. The constructional detail that differentiates the receiver from the transmitter is the INERTIA DAMPER, shown in figure 3–11. A synchro is similar in some ways to an ordinary small AC motor. Under certain conditions, if the shaft is turned suddenly, it will oscillate violently or spin continuously at high speed. The function of the inertia damper is to prevent this. The damper is a heavy metal

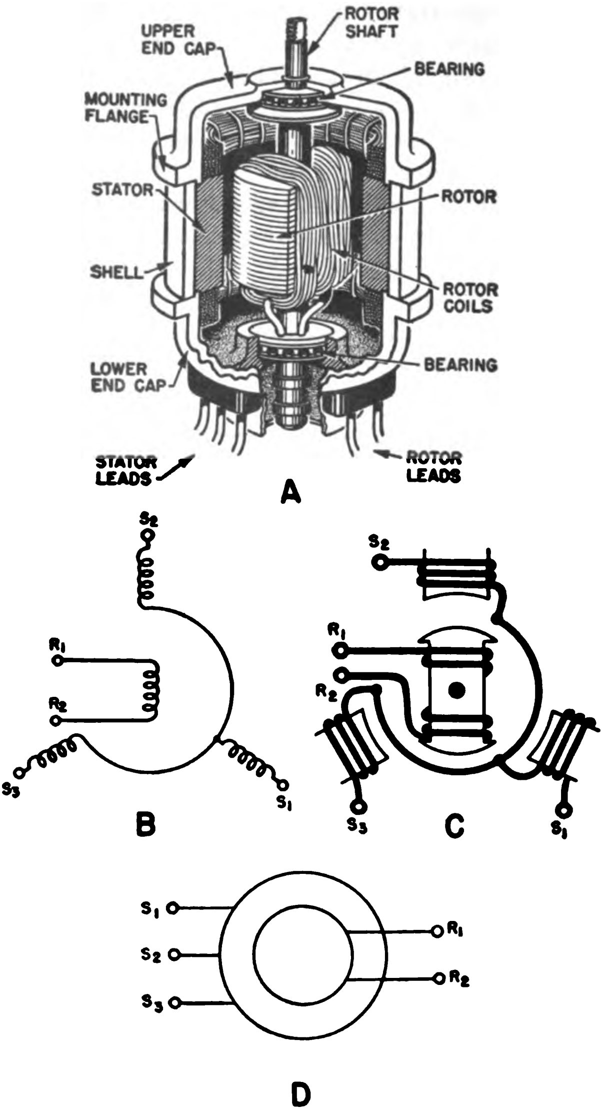


Figure 3–10.—Synchro transmitter. A. Cut-away view. B, C, D. Schematic symbols.

flywheel, mounted so that it turns freely on the shaft for about 45°, and then runs into a keyed bushing. The bushing is fastened to the shaft so that it can turn on the shaft only with a great deal of friction. For slow changes in the position of the shaft the flywheel simply follows along without much effect. If the shaft begins to turn suddenly, the flywheel tends to stand still, so the friction disc acts as a brake, slowing down the motion of the shaft. Thus the shaft never

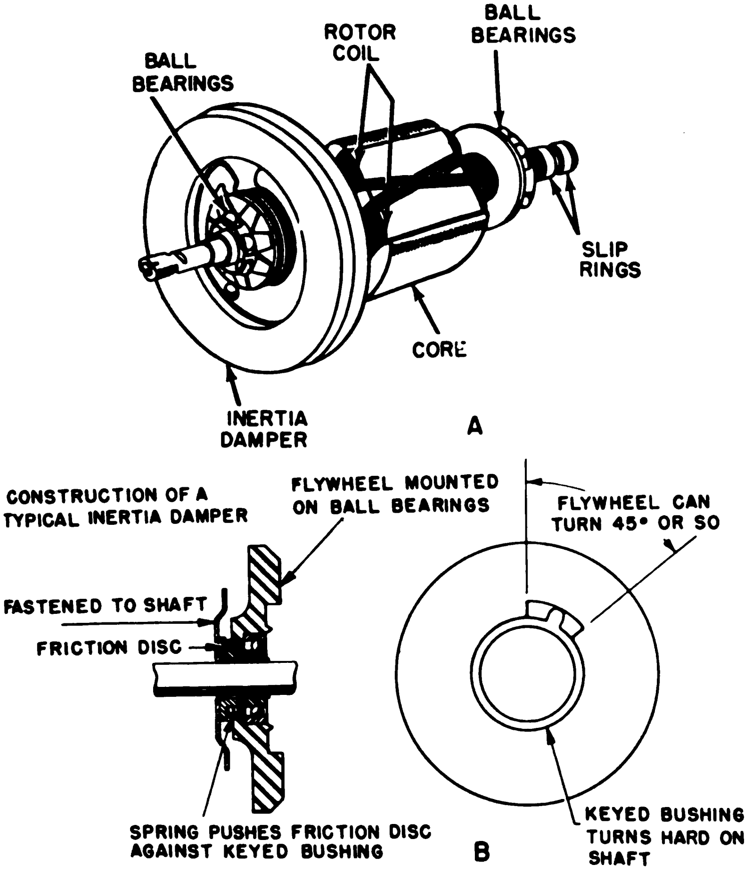

BALL BEARINGS
ROTOR COIL
BALL BEARINGS
SLIP RINGS
CORE
INERTIA DAMPER
A
CONSTRUCTION OF A TYPICAL INERTIA DAMPER
FLYWHEEL MOUNTED ON BALL BEARINGS
FLYWHEEL CAN TURN 45° OR SO
FASTENED TO SHAFT
FRICTION DISC
SPRING PUSHES FRICTION DISC AGAINST KEYED BUSHING
B
KEYED BUSHING TURNS HARD ON SHAFT

Figure 3-11.—Rotor of a synchro receiver, showing operation of damper.

gets going fast enough to start oscillating or spinning. If oscillation or spinning occurs it is a pretty sure sign that something is wrong with the damper, and the synchro should be replaced.

The transmitter, however, since it is always geared to some larger movable element, cannot turn of itself and therefore requires no damper to prevent it from becoming a runaway.

Functioning of the Synchro

Now let's consider how a synchro works.

As you remember from the basic course in electricity, an electric current flowing in a wire produces a magnetic field. When it's an alternating current, the field expands and contracts and reverses its polarity as the input current does. And if an electrical conductor (such as a coil of wire) is in the field, the field, as it expands, contracts, and reverses, induces AC voltages in the conductor. This is essentially the principle of the transformer.

Now the synchro, like many other AC devices that are not actually called transformers, has many of the characteristics of a transformer and utilizes transformer action to function. In figure 3–12 we see a synchro transmitter and a synchro receiver connected so that the receiver will follow the transmitter. Note that R1 on each is connected to the same side of the AC supply line, and R2 on each to the other side. Note also that S1, S2, and S3 of the transmitter are connected respectively to S1, S2, and S3 of the receiver. In figure 3–12, *A*, both synchros are positioned at "electrical zero." (We'll take up that term later.)

But where is the transformer action? First, consider the rotors, both energized (or EXCITED) by 115-volts AC. They are both producing magnetic fields which expand, contract, and reverse polarity 120 times a second (since this is 60-cycle current). These fields induce voltages in the synchro stators. Other things being equal, voltages induced in a coil by another are greatest when the axes of the two coils are parallel, and falls off as they deviate from parallelism,

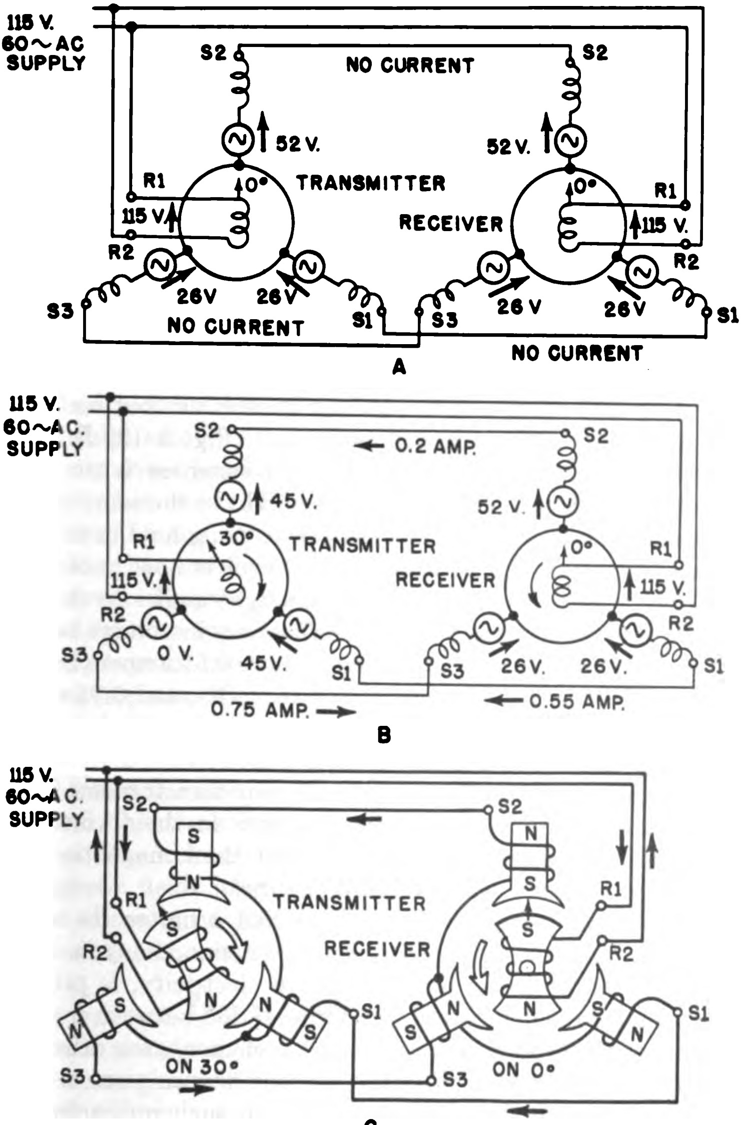


Figure 3-12.—Functioning of a synchro system.

until at a right angle the voltage induced is zero. So the induced voltage is highest (52 volts) in the stator coil whose axis is in line with that of the rotor coil, while the voltage in each of the other two stator coils is 26. That's transformer action.

But no current flows, because the output voltages of the two synchros are not only equal in amount, but also in DIRECTION at any instant. This shouldn't be hard to understand. The INPUT voltages are always in the same direction, because of the way the two rotors are connected to the line. And the rotor of one synchro is in exactly the same relationship to its stator coils as the other's rotor is to its own stator coils. Hence, equal voltages—and no current because the voltages always oppose each other.

Now let's move the transmitter's rotor 30°, but we'll keep the receiver at its original position. (Fig. 3–12, *B.*) The relationship of the coils in the two synchros is no longer parallel. The receiver stator coils still have the same induced voltages, because the receiver rotor is being held in the same position. But the transmitter's S1 coil is now putting out 45 volts, as is S2, while S3, now at right angles to the rotor coil, is putting out zero. With differences in voltage between the two synchros, we have current flow: 0.55 ampere between the two S1 coils, 0.2 ampere between S2s, and 0.75 ampere between S3s.

Now you can see there's current flow, and that explains the synchros' transformer action. But transformers in general are pretty sedentary devices, and do their work without moving anything more material than magnetic fields. What makes the synchro receiver turn?

We've said that the synchro is like a motor (as well as like a transformer). Now, motor action, as you should remember from the basic course in electricity, is produced by the torque developed in the interaction between magnetic fields—one produced by a rotatable element, the other by a stationary element. Without current flow in BOTH the synchro rotor and the synchro stator, no such interaction can develop—hence, with no currents in their stators, the synchros in figure 3–12, *A*, had no motor action. But in figure 3–12, *B*, you see currents flowing in the stator windings, and they produce magnetic fields which interact with those of the rotors to produce torque.

Because synchros are AC devices, and alternating currents are perpetually changing, we are obliged, in order to show the currents and magnetic polarities that produce the torque, to take an "instantaneous snapshot" to show currents and polarities existing at one instant in the circuit shown in figure 3–12, *B*. The "instantaneous snapshot" is shown in figure 3–12, *C*.

Look first at the receiver. The currents flowing in it during this instant produce fields that cause mutual attraction and repulsion between stator and rotor poles. These forces tend to turn the rotor COUNTERCLOCKWISE (as shown by the white arrow)—that is, in the same direction as the transmitter rotor has been turned. And the receiver rotor does turn that way, under normal circumstances. In the transmitter, on the other hand, the currents produce magnetic fields that exert CLOCKWISE torque (as shown by the white arrow). But because the transmitter is always coupled to another device too massive or with too much friction for it to turn, its rotor can never yield to its torque. So, always, the RECEIVER rotor moves. And, as it approaches the same position relative to its stator that the transmitter's rotor bears to the transmitter stator, the more nearly equal become the stator voltages, the smaller grow the stator currents, and the weaker the stator fields. At exact correspondence, the voltages equalize, the currents become zero, the magnetic fields produced by the stator become negligible, and there is no further torque. The process repeats every time the transmitter rotor is turned.

Zeroing Synchro Receivers

We have already seen that turning the rotor of a synchro while it is energized changes the voltages in each of the stator windings. If you consider parts *A* and *B* of figure 3–12 carefully, it will be clear to you that the pattern of voltages in the stator windings is different for EVERY position of the rotor with respect to the stator. (If you want more explanation of this fact than there is space for in this course, you can read up on it in OP 1303.) And the converse is true also: Changing the pattern of voltages applied to the stator windings will cause a change in the rotor's position (if it is free to turn) or will cause current to flow in the lines connecting the stator windings (if the rotor is not free to turn).

Since there is a specific pattern of stator voltages for every position of the rotor with respect to the stator, it's obvious that if we intend to use synchros to transmit quantitative information, we must have a starting point or zero position in order to calibrate the synchro system. This zero position is characterized by the following voltage pattern (all in the same phase) between the points designated:

Points	*Voltage*
R1—R2 (rotor)	115
S1—S2 (stator)	78
S2—S3 (stator)	78
S1—S3 (stator)	0

When you apply these voltages, all in the same phase, to a synchro receiver, its rotor will turn to ELECTRICAL ZERO position. When you energize a synchro transmitter rotor with 115-volts 60-cycle AC, it will be in ELECTRICAL ZERO position only if the stator output voltages agree with this pattern.

You're not expected to try to change the electrical characteristics of any synchro. In general, when you ZERO a synchro, it means that you adjust it MECHANICALLY so it will work properly in a system in which other synchros are zeroed. Depending on the specific assembly involved, this means that you loosen the synchro mounting, turn the entire synchro unit as required to obtain zero reading, and secure it in its new position. Or you may loosen the shaft or dial coupling to turn the shaft, dial, or some intermediate gear.

You zero a synchro receiver by applying the proper voltages to hold it on electrical zero while its dial (or other output mechanism) is adjusted to zero reading. The best way, which can be used if the synchro stator lead connections can be readily changed, is to reconnect the stator leads as in figure 3-13, *A*. The shaft will turn definitely to 0°. Set the dial to its zero reading while the receiver is connected this way.

But—do NOT leave a synchro receiver connected this way longer than is necessary to zero it: 115 volts is applied between S2 and S1-S3 instead of the normal 78 volts, and the synchro will overheat. If a receiver has to be held on zero for more than a few minutes, use a variac or autotransformer and connect as in figure 3-13, *B*.

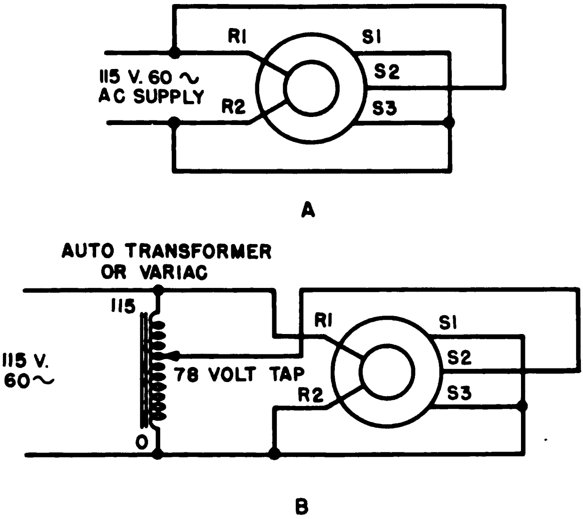


Figure 3-13.—Zeroing a synchro receiver, using 115-VAC supply.

When the receiver is installed in an equipment and its connections can't be changed easily, you can use a zeroed synchro transmitter's output to provide the proper voltages. Proceed as follows:

1. Leave the normal circuit connected, as in figure 3-14. (If S1 and S3 are reversed, don't bother changing them; this won't affect the results.)

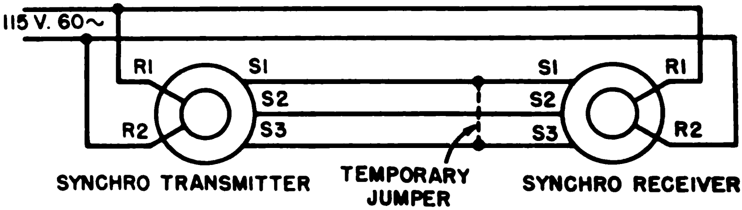


Figure 3-14.—Alternate method of zeroing a synchro receiver.

2. Make sure that the synchro transmitter has been correctly zeroed, and that the connecting wires are properly installed. Then set the transmitter in zero position. Make sure that it stays there while you are adjusting the receiver. Connect a temporary jumper from S1 to S3 (as shown by the dotted line in the diagram). This holds the receiver more definitely on 0°, so its dial can be set more easily.

Caution: If the receiver shaft moves more than a fraction of a degree when this jumper is connected, the transmitter is NOT set on 0°, and should be rechecked.

3. Unclamp the case of the receiver. Turn it (or loosen the dial or output coupling and turn it) until the dial (or output coupling) is at zero while the receiver is connected this way. (It sometimes helps to get the dial set more accurately if the jumper is connected and disconnected several times so the dial moves very slightly.)

4. Clamp the synchro in position when finished, and remove the jumper.

You will have little occasion to work directly with synchro transmitters, since they are not installed in gun mounts, and since those in main-battery turrets are maintained by fire control personnel. We therefore shall not in this chapter discuss how to zero them or perform any other operations on them.

Making Connections to Synchro Receivers

You should be especially careful in making connections to synchro receivers. If you interchange the S1 and S3 leads, you will REVERSE the direction of rotation, so that the receiver will rotate clockwise when the transmitter is rotating counterclockwise. If you interchange any other stator leads, you introduce 120° errors in the receiver's response. And if you interchange the R1 and R2 leads, you cause the receiver to be 180° out.

The Bearing-Mounted Synchro Receiver

The type of synchro receiver that we've discussed so far is a common one, but not the only one. You will come across the BEARING-MOUNTED receiver in zero-readers and in parallax mechanisms. Let's look at this type of receiver and its application for a moment.

The bearing-mounted synchro (fig. 3–15) is electrically just like the others we have been discussing so far. But its case is mounted on ball bearings and is secured to a gear, which in the figure is driven by a worm so that the whole assembly, stator and all, can be turned on its bearings. In a bearing-mounted synchro the three stator leads, as well as the rotor leads, are brought out to slip rings so that stationary brushes can maintain contact with the synchro as it turns

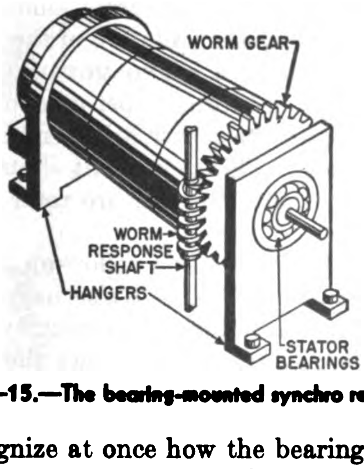


Figure 3–15.—The bearing-mounted synchro receiver.

You can recognize at once how the bearing mounted synchro is used in the zero-reader. Suppose it's in a train indicator-receiver or indicator-regulator. An input to the receiver from the transmitter moves the receiver dial off zero.

The trainer cranks his handwheels. As the mount trains, corrected response from the training pinion turns the gear on which the synchro assembly is mounted, bringing the index mark on the dial back toward the index mark on the face of the indicator as the trainer matches pointers. (The rotor maintains the same angular relationship with the stator as long as the rotor is energized and the transmitter rotor does not itself move. That's why the rotor turns with the stator.) This sequence of operations applies not only in manual but also in local power. And in automatic it serves as a check on the operation of the whole remote control system.

The bearing-mounted synchro is used also for automatic follow-up. A common example, with which you are well acquainted, is the parallax corrector mechanism on 5''/38 mounts. This has been discussed in an earlier course in this series, without details on just how the follow-up was accomplished. Now here is the whole story, illustrated with a schematic in figure 3–16. (This figure does not show the entire gear train; OP 1066 shows that in detail for the 5''/38 single mount.)

The general idea of the automatic follow-up mechanism, shown in figure 3–16, is that rotation of the parallax synchro rotor closes a circuit to a SERVO MOTOR, which drives the parallax mechanism until the proper amount of parallax has been introduced into the power drive and into the parallax ring dial indication. This movement shuts off the current to the servo motor until the synchro rotor moves to a new position.

The heart of the automatic follow-up is, appropriately enough, called a HEART CAM. It also happens to be heart-shaped. The reason is functional, not symbolical, as an inspection of figure 3–17, which shows the heart cam part of the mechanism, will indicate.

Part *A* of figure 3–17 shows the heart cam at neutral position, with the follower in the detent of the cam. When the synchro rotor begins to turn the cam, the follower and contact arm turn with it to close the circuit to the servo motor through one side of the double-pole switch. As the synchro-

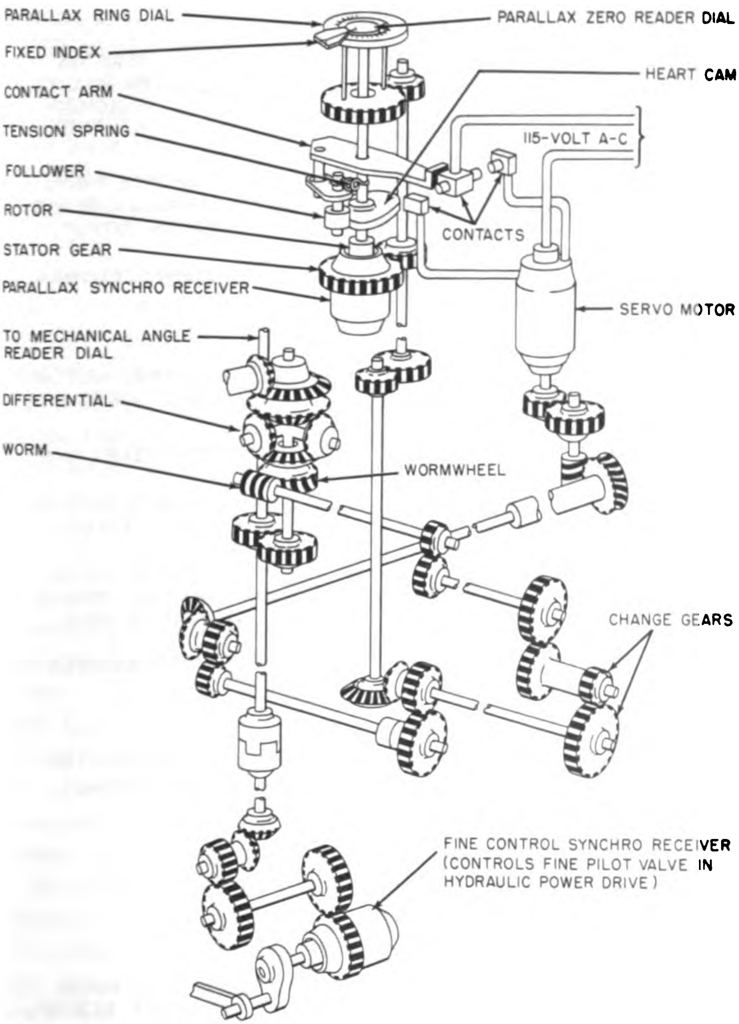

PARALLAX RING DIAL
FIXED INDEX
CONTACT ARM
TENSION SPRING
FOLLOWER
ROTOR
STATOR GEAR
PARALLAX SYNCHRO RECEIVER
TO MECHANICAL ANGLE READER DIAL
DIFFERENTIAL
WORM
PARALLAX ZERO READER DIAL
HEART CAM
115-VOLT A-C
CONTACTS
SERVO MOTOR
WORMWHEEL
CHANGE GEARS
FINE CONTROL SYNCHRO RECEIVER (CONTROLS FINE PILOT VALVE IN HYDRAULIC POWER DRIVE)

Figure 3-16.—Application of bearing-mounted synchro in automatic follow-up system. (Parallax mechanism in GE power drive for 5"/38 single mount.)

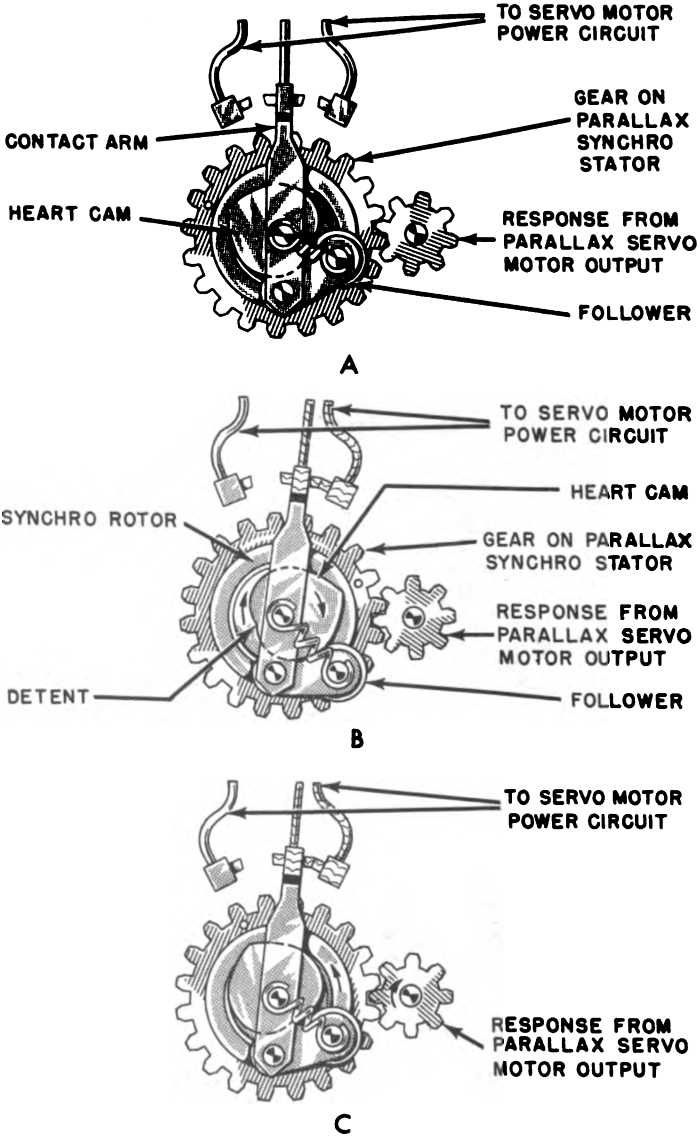

TO SERVO MOTOR POWER CIRCUIT
GEAR ON PARALLAX SYNCHRO STATOR
CONTACT ARM
HEART CAM
RESPONSE FROM PARALLAX SERVO MOTOR OUTPUT
FOLLOWER
A
TO SERVO MOTOR POWER CIRCUIT
HEART CAM
SYNCHRO ROTOR
GEAR ON PARALLAX SYNCHRO STATOR
RESPONSE FROM PARALLAX SERVO MOTOR OUTPUT
DETENT
FOLLOWER
B
TO SERVO MOTOR POWER CIRCUIT
RESPONSE FROM PARALLAX SERVO MOTOR OUTPUT
C

Figure 3–17.—Functioning of the heart cam.

driven cam continues to turn on one of the sides of the cam, the contact arm and follower can follow it no further. So they stop, and the roller of the follower rides up out of the detent onto the side of the cam. (Fig. 3–17, *B*.)

When the servo motor turns, its output rotates the gear-mounted synchro in the opposite direction (fig. 3–17, *C*). As the heart cam approaches its original position, the follower rolls back into the cam detent. The contact arm then moves with the cam just far enough to open the circuit.

At the end of this operating cycle, the cam and follower are back to their starting position.

The advantage of the heart cam here is, first, that it places a minimum load on the synchro. (All synchros require minimum load for maximum accuracy.) Second, it permits full synchro rotation even if, through casualty, the servo motor fails to operate. (As you remember from a few pages back, a synchro receiver that stays out of correspondence with its transmitter carries current, and most synchro stators are designed to carry current only intermittently.) Thus the synchro merely controls the movement of the parallax mechanism while the servo does all the work.

You can see how this works in the parallax mechanism by returning for a moment to figure 3–16. First a signal from the transmitter in the computer turns the parallax synchro rotor. This turns the zero reader dial to indicate the signal, and turns the heart cam to close the circuit to the servo motor. The servo motor's rotation is transmitted through the gear train to the synchro stator gear, driving it (and the parallax ring dial) until the follower rolls into the heart cam detent and the servo motor switch opens the circuit.

Another branch of the gear train transmits the parallax correction through the change gears and a differential to the fine control synchro receiver of the regulator (where it turns the synchro stator), and to the mechanical angle reader train dial.

Zeroing the Bearing-Mounted Synchro

Before we leave the bearing-mounted synchro, you should know how to zero it.

The stator of the synchro is usually geared to other units in the assembly, and there is usually a shaft coupling or gear that can be loosened to set zero. The zeroing procedure is:

1. Set the unit to which the stator is geared in its zero position.
2. Remove all stator connections and reconnect the synchro as in figures 3–13 or 3–14. The rotor shaft will turn to zero position with respect to the stator.
3. If a dial is used, loosen the mechanical connection to the stator and turn it by hand until it is in zero position. Then retighten.
4. If a heart cam mechanism is used, the roller is likely to be turned out of the detent when zero voltage is applied. Loosen the mechanical connection to the stator and turn the cam mechanism by hand until the follower is in the detent and the contacts are in central position, as in figure 3–17, *A*. Then tighten the mechanical connection.
5. Deenergize the synchro. NEVER, as we have mentioned before, leave the synchro energized as in the circuit shown in figure 3–13, *A*, any longer than absolutely necessary for zeroing, because it may burn out under the excessive voltages applied.

The Synchro CT

There are several other types of synchros also used in fire control equipment, but of these only one is used in gun mounts. That is the SYNCHRO CONTROL TRANSFORMER (or synchro CT).

The typical synchro CT application in a gun mount is in the York Safe and Lock electrohydraulic power drive in 40 mm mounts, and in amplidyne power drives, where it is used to compare gun order (an electrical input) with corrected response from the mount (a mechanical input) and put out the difference as an error signal (electrical) to the input of the control amplifier. The three stator coils of the synchro CT serve as the electrical input. They are wound with more turns and finer wire than other synchros, so that they have high impedance and draw little current. The rotor winding, also of fine wire and high impedance, provides the output to the amplifier. The rotor is connected by gearing to the elevation or train mechanism of the mount. Since all the windings carry very small currents, the torque developed is negligible. There is no connection to the 115-VAC line. And, unlike the synchros we have studied, as the rotor is turned, there is practically no effect on stator voltages. It's **ALL transformer—no motor action whatever.**

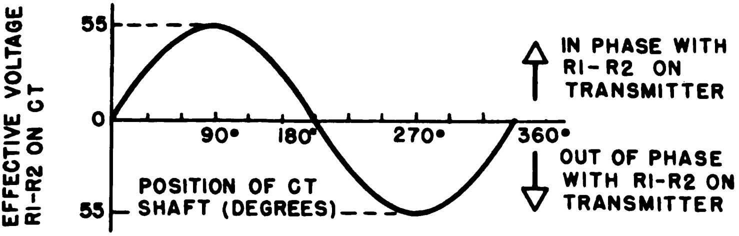


Figure 3–18.—Output voltage variation of a synchro CT connected to a synchro transmitter on electrical zero.

Then how does the CT electrically indicate the difference between its electrical input to the stator and its mechanical input (rotor position)?

This is shown graphically in figure 3–18. If the output of a synchro transmitter at electrical zero is fed into the CT stator, while the CT rotor is turned counterclockwise one revolution, the voltage output of the CT rotor winding varies in a sine curve from zero to 55 volts. The POLARITY of the CT's output (as compared with the synchro transmitter's own polarity or phase) is the same (indicated as plus in the figure) during 180° of its revolution, and opposite (indicated as minus in the figure) during the remainder of the revolution.

Note that there are TWO zero points (no voltage output) on the graph. Except for these, EVERY position of the rotor yields an electrical output different from that of every other position in voltage, polarity, or both. These differences in amplifier input result in differences in amplifier output to stroke motor or amplidyne generator field (in YS & L and amplidyne power drives, respectively) which cause the power drives to move the gun mount in accordance with the new gun order.

Zeroing the Synchro CT

The fact that a synchro CT has TWO no-output positions somewhat complicates the process of zeroing it. Of course, only one of these corresponds to electrical zero. The general rule is that the synchro CT is at electrical zero position when the following conditions exist:

1. Its output voltage is zero.
2. A slight turn counterclockwise from this position produces a voltage from R1–R2 on the CT that is the same in phase (or polarity) as the voltage from R1–R2 of the synchro transmitter.

To zero a CT, you don't have to go through this process, however. The preceding paragraph does not describe the standard method for determining electrical zero, but only the definition for it. (Using this as a method for determining electrical zero on a CT would require the use of instruments—such as an oscilloscope—in whose use you are not trained.) A recommended method for setting a CT to electrical zero is as follows:

1. Set the unit whose position the CT transmits, accurately in its zero position.
2. Now you will need an AC voltmeter that reads up to 200 on one scale, and down to 0.1 on another. Remove all other connections from the CT's leads, set the voltmeter on its 200-volt scale and connect as in figure 3–19, *A*.
3. Unclamp the CT and turn it until the meter reads minimum (about 40 volts). The CT is now approximately on 0°. Reconnect as in figure 3–19, *B*.
4. Set the voltmeter on its lowest scale and turn the CT until you get minimum reading. Clamp the CT in this position and reconnect all leads normally.

Important. Never leave a CT connected this way any longer than is necessary to zero it. Because 115 volts is applied where the voltage is normally lower, the CT will overheat.

Synchro Speeds and Sizes

You know, of course, that synchros come in various SPEEDS, because very often the accuracy required in transmission exceeds that which is characteristic of the synchro. So one synchro (1-speed or 2-speed) transmits the COARSE indication while another (often 36-speed) transmits the FINE indication. The "speed" number indicates the ratio of the synchro's rotation to the actual quantity being transmitted. For

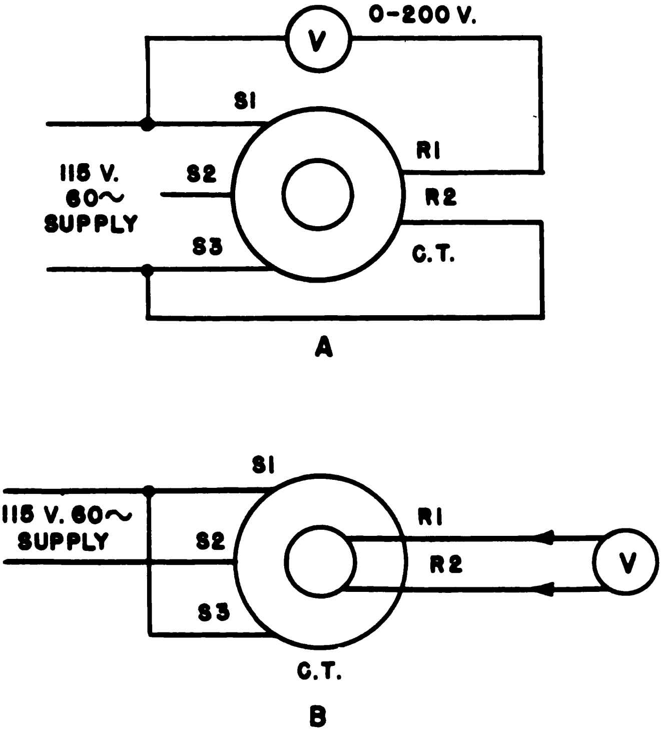


Figure 3-19.—Zeroing a synchro control transformer.

example, a 2-speed synchro used to transmit elevation angle rotates 90° when the angle to be transmitted is 45°. Since the inherent error of the synchro is a function of its ACTUAL rotation, a 2-speed synchro halves the error of transmission. A 1-speed synchro, of course, rotates 45° to transmit 45°. Synchros used at speeds higher than 2 are always paired with 1-speed or 2-speed synchros. The low-speed synchro gives the coarse indication; the high-speed synchro's fine indication is added to the coarse indication to give the exact quantity transmitted with an accuracy much better than that of the coarse unit alone. The fine synchro cannot be used alone because each of its positions corresponds to a number of positions of the coarse synchro. For a further review of the coarse-fine indication principle, see *Gunner's Mate 3*, volume 1 (NavPers 10158–A).

Synchros are designated by marks and mods, like most ordnance equipment. The mod numbers are coded according to the manufacturer of the synchro. Synchros also come in several sizes, so that larger transmitters can each operate several receivers or other synchro units. And synchro designations also include code numbers to indicate whether the unit is bearing-mounted, flange-mounted, nozzle-mounted, whether it is a high-speed unit, and so on. For details on synchro designations, see OP 1303.

CONCLUSION

In this chapter we began with a brief review of the characteristics of electricity as they are important in the mechanisms and circuits you are expected to deal with. Then we took up firing and lighting circuits, and examples of the electrical measuring instruments that you use in performing electrical maintenance operations. Last, we considered synchros—their principles of operation, their construction, and their adjustment.

The trend at present is to require more in the way of electrical knowledge and skills of the Gunner's Mate than has been traditional in the past. As gun and mount mechanisms tend more and more to be electrically powered and controlled, you can expect this trend to continue. So it will be worth your while to familiarize yourself with the operation and maintenance of electrical devices in your gun mounts; you'll find it valuable. And in this book, you will find, we shall hark back more than a few times to what has been taken up in this chapter.

QUIZ

In each of the following, select the BEST answer.

1. The process by which a magnetic field moving with respect to an electrical conductor produces a voltage in the conductor is called:
   - a. Conduction
   - b. Induction
   - c. Thermocouple
   - d. Electrolyte
2. Which of the following is ALWAYS true in a series circuit?
   - a. The voltage across each item in the circuit is the same as that across all the other items in the circuit.
   - b. The voltage across each item in the circuit is inversely proportional to the current.
   - c. The current in each item in the circuit is proportional to its resistance.
   - d. The current in each item in the circuit is the same as that in all the other items in the circuit.
3. Which of the following components of the typical firing circuit will NOT function on DC?
   - a. Transformer
   - b. Primer filament
   - c. Firing snap switch
   - d. Battery
4. Which of the following components of the typical firing circuit completes the circuit to the primary winding of the firing transformer?
   - a. Pointer's firing key
   - b. Remote firing key
   - c. Firing snap switch
   - d. Safety contact
5. A fully charged lead-acid type storage battery will give a hydrometer reading of about
   - a. 1.000
   - b. 1.170
   - c. 1.300
   - d. 1.835
6. Which of the following operations may you, as a Gunner's Mate, perform on a d'Arsonval type meter?
   - a. Adjust counterbalance weights
   - b. Adjust iron core
   - c. Adjust zeroing screw
   - d. Remove face plate

7. Which of the following instruments must be used with the circuit DEENERGIZED?
    a. Ohmmeter
    b. Ammeter
    c. AC voltmeter
    d. DC voltmeter
8. Suppose you want to measure the voltage in a line, but you are not sure which range on your multimeter is the best to use. What is the best principle to follow in connecting the instrument for the first time?
    a. Set up the instrument as an ammeter, and put it across the line.
    b. Set up the instrument for the lowest voltage range, and put it across the line.
    c. Set up the instrument for the highest voltage range, and put it across the line.
    d. Set up the instrument for the voltage range you estimate as the best, and connect it in series into the circuit.
9. As a synchro transmitter turns more and more out of synchronism with the synchro receiver to which it is connected,
    a. Rotor voltages decrease
    b. Rotor voltages increase
    c. Stator currents decrease
    d. Stator currents increase
10. What is the characteristic by which you can tell that a synchro receiver or transmitter is at electrical zero position?
    a. All stator voltages will be zero.
    b. The synchro will be in synchronism with its transmitter or receiver.
    c. All stator currents will be zero.
    d. Rotor and stator voltages will conform to a certain pattern.
11. Which of the following errors in wiring will cause a synchro receiver to follow the transmitter 180° out?
    a. Interchange R1 and R2
    b. Interchange S1 and S2
    c. Interchange S1 and S3
    d. Interchange S2 and S3
12. The output of a synchro CT is
    a. Rotation of the rotor shaft
    b. Voltage from the R1–R2 winding
    c. Voltage from the S1–S2 winding
    d. Voltage from the three stator windings, taken together

CHAPTER 4

FIRE CONTROL

INTRODUCTION

A hundred and fifty years ago, the Gunner's Mate was a jack of all trades relating to armament. Any competent Gunner's Mate was expected to know how to load, aim, and fire any gun, from small arms to hundred-pounder cannon and larger. He was expected to know how to make up mines (then called torpedoes) and other charges, and how to handle black powder. And that was about all. Of course, he was also expected to be a competent seaman, but so far as armament goes, he didn't have to know any more because there just wasn't much more to know.

Don't get the idea that the old-time Gunner's Mate had an easy job. He had arduous, dangerous work to do, and a good deal of it, without the help of the multitude of labor-saving and life-saving devices that you have at your disposal now. But that doesn't change the fundamental point here, which is that a hundred and fifty years ago it was possible for one man to master, without mental strain, ALL the skills that related to the efficient operation and maintenance of the armament of the time.

As naval armament became more specialized and complex, the body of skills and knowledge that the Gunner's Mate was expected to master became correspondingly specialized and complex, and other specialists like FT's, TM's, AO's, and MN's had to take over part of what had at one time been exclusively Gunner's Mate's work. But today the Gunner's

Mate, though he too has specialized, is still expected to be something of an expert on armament. Much of this book is devoted to aspects of armament other than guns, and to the study of techniques and gear not narrowly concerned with what is within the confines of the gun mount shield.

Fire control is certainly no novelty to you. Nobody has to remind you that the Fire Control Technician's work is as immediately essential to the effectiveness of your ship's armament as is yours. So it isn't surprising that the *Qualifications for Advancement in Rating* state that you are expected to master certain skills that you ordinarily associate with the Fire Control Technician. This chapter is intended to give you the background that you will need to fulfill this part of your job. It will also serve as a convenient review of the principles of fire control with which you are already acquainted from earlier courses in this series, as well as a basis for study of chapter 12, on battery alignment.

THE FIRE CONTROL PROBLEMS

Fire control is problem-solving—the problem of destroying the target with the ship's armament. There are three big problems in fire control from shipboard—the SURFACE TARGET problem, the AIR TARGET problem, and the UNDERWATER TARGET problem. In this course we shall not go into the problems of fire control from aircraft, subsurface craft, or land forces.

In the surface problem, we take estimated values of target course and speed, measured range, relative bearing, own ship's course and speed, and certain other factors such as wind direction and speed. We then resolve ship and target motion into linear rates in and about the line of sight, and compute the predicted future position of the target. Then we compute necessary ballistic corrections and work out gun orders which will direct projectiles fired from the guns onto the target.

The air problem is similar to the surface problem, but because we are firing at air targets we must measure, in addition, target elevation—the vertical angle between the line of sight and the horizontal—as an additional input.

The underwater problem is similar to the air problem, but upside down, with the attacking ship moving in a horizontal plane above the target. The motions of own ship and target are resolved into horizontal components in and across the sonar bearing or "line of sound" (no line of sight in this problem) to compute the attack course, the time of fire, and (for thrown weapons) the range and bearing of projection.

These brief summaries omit the refinements, but they do give the general idea of what is done in the solution of each problem. In order to understand more clearly just how the fire control problem is solved in each case, we should know something about the gear used. You have already been introduced to most of it in earlier courses in this series; here we shall briefly review what you already know, and take up in some further detail the functions of each type in dealing with the fire control problem.

FIRE CONTROL EQUIPMENT

The types of fire control equipment that we shall take up here include the director, the computer, the stable element, radar, and sonar. (Synchro systems were taken up in the preceding chapter.) What you learn here will not make you an expert on any of these. But this chapter will help you in understanding, using, and maintaining the on-mount equipment concerned with fire control with which you do work.

The Director

In general, we can say that the fire control director's function is to introduce into the fire-control system the target's position and rate of motion in terms of range, bearing, and elevation. The exact way in which this is done, and the extent to which it is done, depends on the kind of system concerned. For example, the director in a surface system is not designed to introduce information regarding the target's altitude. Directors in dual-purpose and surface systems include optical level and cross-level equipment and optical rangefinders. These are not found in machine-gun directors. Most directors function optically; some include provisions for partial or full radar control.

In the Mk 37 director, illustrated in figure 4-1, you will find an optical rangefinder, pointer's and trainer's telescopes and controls, radar equipment, power drives for positioning the director, an observation hatch that is used by a control officer (who may also serve as a spotter), and a slewing sight for positioning the director to pick up the target. The primary functions of the director, as we have already seen, are to locate the target by its bearing, elevation, and range. Its secondary functions can be summarized by saying that it is the control station for the entire fire control system. When the system is functioning as designed, all units operate

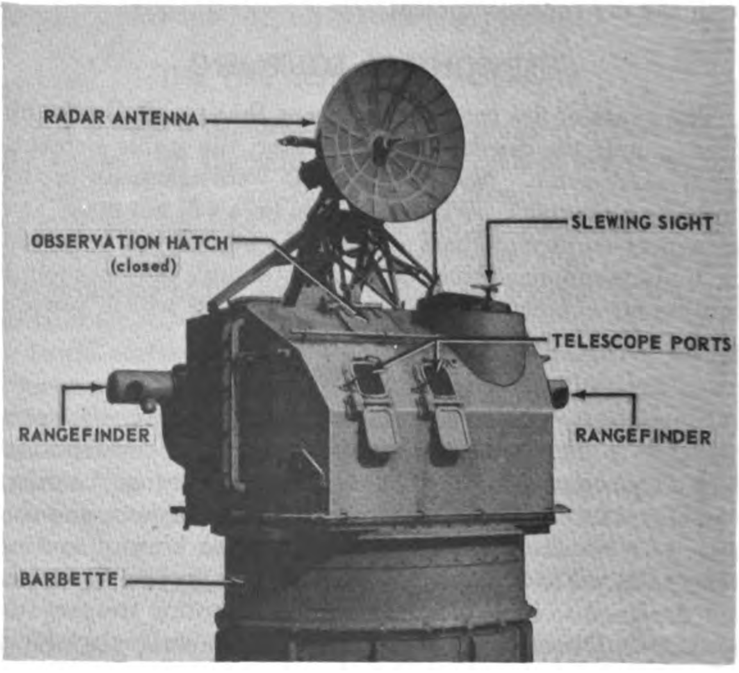


Figure 4-1.—Mk 37 director.

by remote control from the director. As long as the problem is being solved correctly, only the gun-loading crews have work to do. All other personnel merely stand by and observe, ready to step in to help when necessary. When changes in the problem set-up are necessary, the director crew can accomplish this by remote control. In order to control the entire system, the director is equipped to:

1. Make initial estimates of target angle, target horizontal speed, and rate of climb.
2. Spot service projectile fire and transmit these spots.
3. Compute and transmit searchlight train and elevation orders.
4. Spot star-shell fire and transmit these spots.
5. Control rate calculations in the computer by correcting settings of target angle, target horizontal speed, and rate of climb.

Directors for main-battery (surface) systems omit features having to do with target elevation measurement. Machine-gun fire control directors perform also most of the functions of the COMPUTER, which we shall take up next. We shall consider directors in somewhat further detail later in this chapter in connection with the systems of which they are part.

The Computer and the Stable Element

In dual-purpose and surface fire control systems, the computer is the "thinking" part of the system. In the Mk 37 dual-purpose system (fig. 4–2) the computer is linked by synchro transmission lines with the director and the gun mounts, and mechanically with the STABLE ELEMENT. This is a gyroscopic device whose main function is to maintain a true horizontal under all conditions of pitch, roll, and other changes in the ship's attitude, and to transmit the amount of deviation from the horizontal to the computer.

The inputs to the computer include the director outputs and a mechanical input of level and cross-level from the stable element. The computer outputs include gun train and elevation orders (including unit parallax corrections),

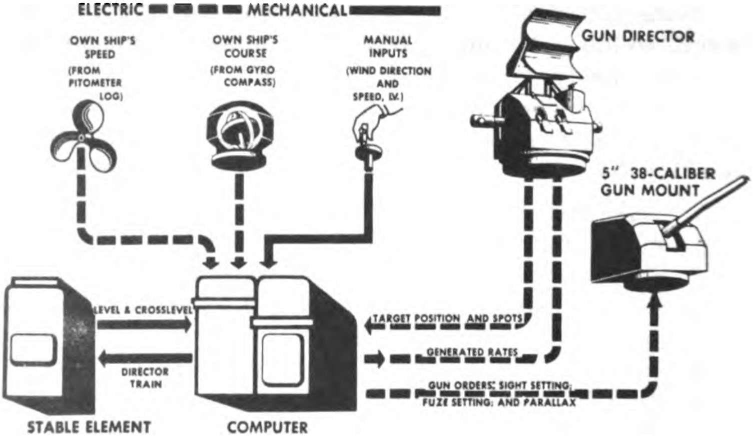

ELECTRIC
MECHANICAL
OWN SHIP'S SPEED (FROM PITOMETER LOG)
OWN SHIP'S COURSE (FROM GYRO COMPASS)
MANUAL INPUTS (WIND DIRECTION AND SPEED, IV.)
GUN DIRECTOR
5" 38-CALIBER GUN MOUNT
LEVEL & CROSSLEVEL
DIRECTOR TRAIN
TARGET POSITION AND SPOTS
GENERATED RATES
GUN ORDERS: SIGHT SETTING; FUZE SETTING; AND PARALLAX
STABLE ELEMENT
COMPUTER

Figure 4-2.—Mk 37 fire control system. (Schematic.)

sight angle, and sight deflection to the gun mount; generated range, bearing, and elevation to the director; and director train to the stable element. (This last is a mechanical output; all the others are electrical.)

The stable element's inputs from and outputs to the computer are given above; in addition, the stable element can control firing by closing the firing circuits at preset values of level or cross-level.

In surface systems, most of the functions of the computer are performed by a RANGEKEEPER, and those of the stable element by the STABLE VERTICAL. There are differences between stable vertical and stable element but this is not the place to go into them.

Figure 4-2 shows in a simplified schematic the flow of data in the dual-purpose gun fire control system based on the Mk 37 director and Mk 1 or 1A computer. Use the figure to review the workings of the system.

Radar

You know that radar is a method for determining, by radio echoes, the presence of objects, their range, bearing, and elevation, for recognizing certain of their characteristics, and for making use of this information. Radar began as rather high-level stuff, but now there are radars right in gun mounts and turrets. Even though you're not expected to maintain radar equipments, you may have to work with them in spotting, and you should know what the general idea is. That is about all this section is intended to give you.

Here are the bare elements of radar set operation. (Fig. 4–3.) A high-powered TRANSMITTER sends out a short pulse of intense high-frequency radiation from a special ANTENNA so that it issues more or less as a beam. Then the antenna is switched to a sensitive RECEIVER, which picks up radio echoes reflected by targets in the path of the beam. The echo (PIP or BLIP) shows up as a bright spot or a kinked line on the screen of a CATHODE-RAY TUBE. (The tube is like that of a television receiver, but you DON'T get a picture—only blips or pips.)

All this happens pretty fast. In one type of radar presentation (type "A"), a beam of electrons sweeps across the tube face at uniform speed in a straight horizontal line, then shuts off. Then a new beam begins crossing the screen again. This (in some radars) happens 10,000 times per second. Each traversal takes 100 millionths of a second (or 100 microseconds). Each time the sweep begins, a TIMER and KEYER cause the radar transmitter to send out its pulse, which moves out at the speed of light (186,000 miles per second or 328 yards per microsecond); then the antenna is switched to receiving until the next pulse.

Now, suppose there is a target at 1,640 yards. Traveling at 328 yards per microsecond, the radar pulse hits it in 5 microseconds, and the energy reflected by the target travels the 1,640 yards back to the ship in another 5 microseconds. The radar antenna (now connected to the radar receiver) picks it up, and the receiver converts it to an impulse to the cathode-ray tube screen.

But during this 10 microsecond interval, the electron beam has moved part of the way across the tube face. The

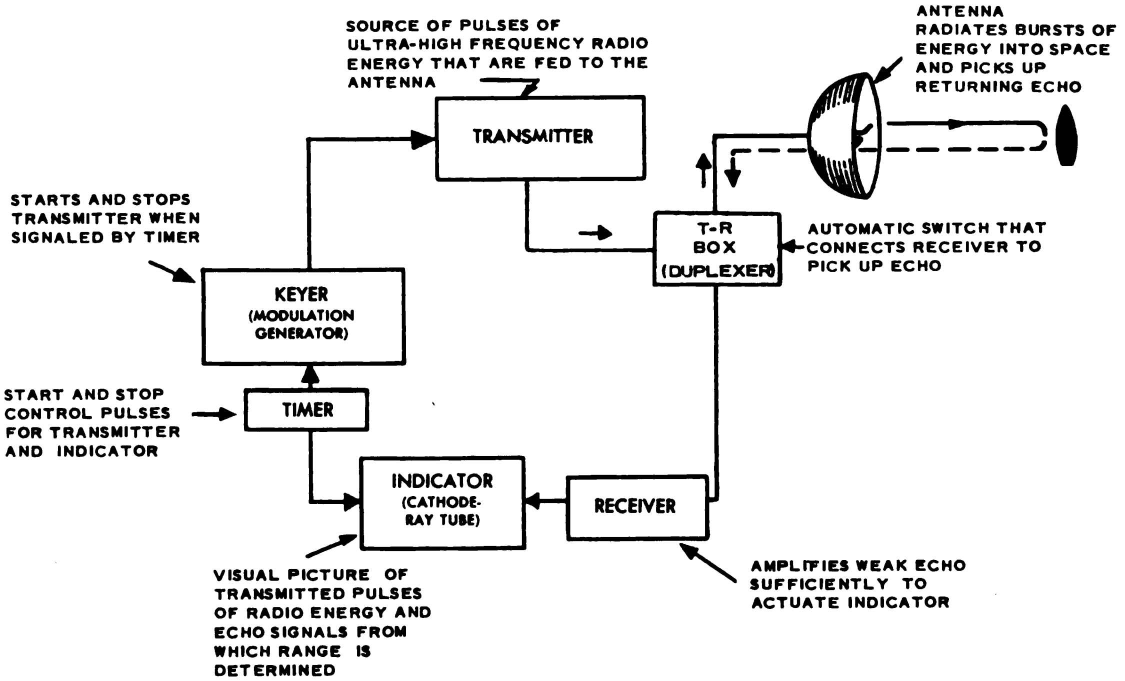

SOURCE OF PULSES OF ULTRA-HIGH FREQUENCY RADIO ENERGY THAT ARE FED TO THE ANTENNA
ANTENNA RADIATES BURSTS OF ENERGY INTO SPACE AND PICKS UP RETURNING ECHO
TRANSMITTER
STARTS AND STOPS TRANSMITTER WHEN SIGNALED BY TIMER
T-R BOX (DUPLEXER)
AUTOMATIC SWITCH THAT CONNECTS RECEIVER TO PICK UP ECHO
KEYER (MODULATION GENERATOR)
START AND STOP CONTROL PULSES FOR TRANSMITTER AND INDICATOR
TIMER
INDICATOR (CATHODE-RAY TUBE)
RECEIVER
VISUAL PICTURE OF TRANSMITTED PULSES OF RADIO ENERGY AND ECHO SIGNALS FROM WHICH RANGE IS DETERMINED
AMPLIFIES WEAK ECHO SUFFICIENTLY TO ACTUATE INDICATOR

Figure 4-3.—Elements of a radar system. (Block diagram.)

reflected echo jogs it up for an instant as it continues to move its appointed way across the tube. That's the pip.

Because of the electron beam's uniform speed across the tube, the position of the pip is exactly proportional to the range of the target, and the tube face can be calibrated for range as shown in figure 4-4.

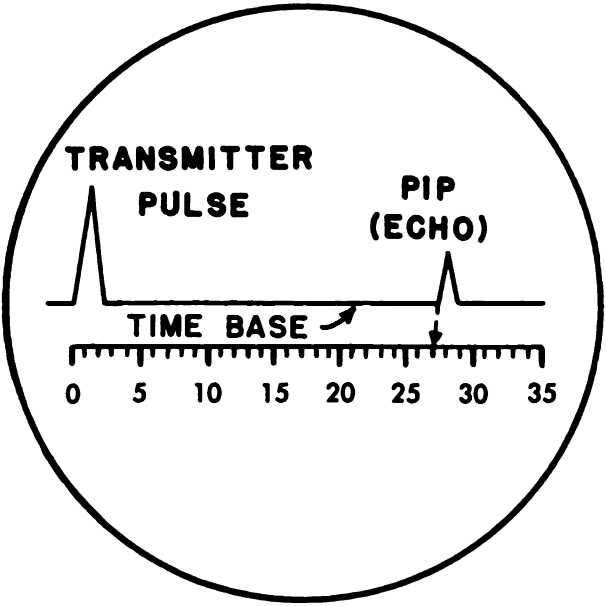


Figure 4-4.—Type "A" radar presentation.

This presentation can also be used to determine bearing. The radar pulse's strength can be plotted in a lobe-shaped pattern, so that as the antenna is trained across the target, the echoes vary in strength as shown in figure 4-5, *A*. Result: the antenna will show the target's bearing when trained to give maximum height of pip. Or two lobes, each of slightly different bearing, can be transmitted alternately. Each will give its own pip, and when the two are of equal height (meaning equal echo strength) the bearing of the target can be established as shown in figure 4-5, *B*.

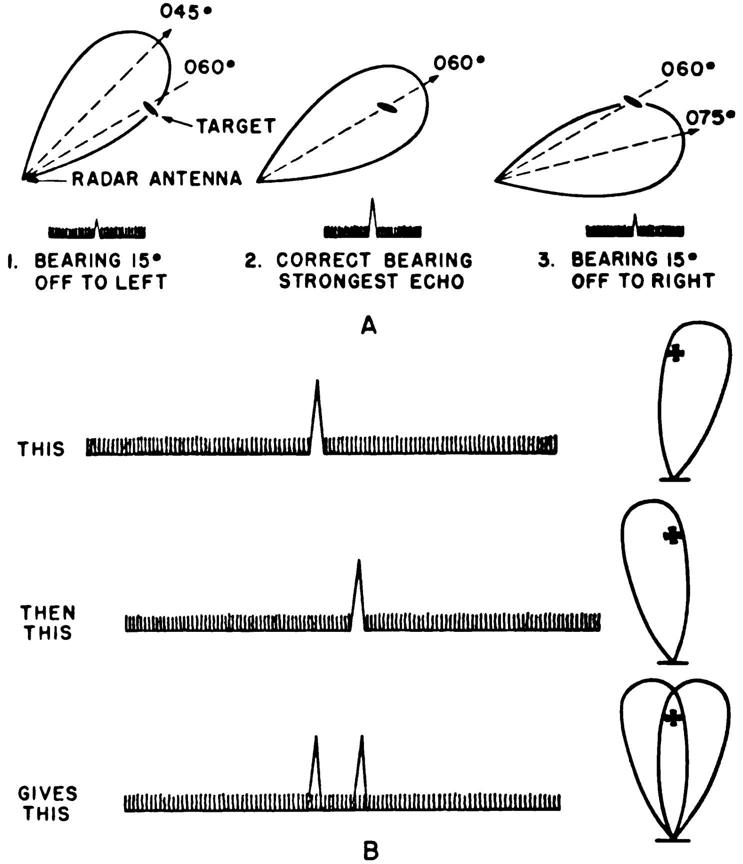

045°
060°
TARGET
RADAR ANTENNA
060°
060°
075°
1. BEARING 15° OFF TO LEFT
2. CORRECT BEARING STRONGEST ECHO
3. BEARING 15° OFF TO RIGHT
A
THIS
THEN THIS
GIVES THIS
B

Figure 4-5.—Determining bearing on type "A" scan. A. Using pip height. B. Lobe switching method.

The type "A" presentation of radar data is only one of several. Another common one is the PLAN POSITION INDICATOR, or PPI-scope. In radars equipped for PPI, the radar antenna is mounted above the ship's structure so that as it revolves continuously in one direction its beam scans the entire surrounding area. The cathode-ray tube face shows a "radar map" of the area being covered, with the antenna at the center of the map, and the path of the radar pulses shown as a glowing line revolving about the center as the antenna revolves. Figure 4–6, *A*, shows, on the left, a photograph of an actual PPI presentation; on the right is diagrammed the way in which range and bearing can be read from the presentation. Targets and other features of the PPI presentation show in glowing light against the background. The inside of the tube face is coated with fluorescent material so that the spots (representing targets and other features) made to glow by the electron beam will not disappear instantly as the beam's bright line revolves slowly about the tube; instead, they continue to glow for some time.

Especially important in fire control radar are the B-scope and the T&E-scope (figs. 4–6, *B* and 4–6, *C*, respectively). The B-scope provides a rectangular presentation of a small segment of the area, with range indicated vertically and bearing horizontally. The T&E-scope presents a view of a plane perpendicular to the antenna axis, with bearing indicated horizontally and elevation vertically. This may sound complicated, but if you look again at figure 4–6, *C*, you'll see that this amounts to a "radar-eye" view of what you would see through a gun sight telescope.

As you know, there are two main kinds of radar equipment aboard ship—SEARCH RADAR and FIRE CONTROL RADAR. Most search radar is characterized by extreme range, and only fair precision; it's used to detect and designate targets by approximate location. It is also used in navigation, and one type is used to control the movements of friendly aircraft. Fire control radar sets, on the other hand, must be able to determine the range, bearing, and elevation of a target with great precision for effective gun fire. They must also have good target resolution; that is, they must be able to distinguish between pips which are very close together, to permit accurate pointing and training, and spotting of splashes.

Surface fire control radar is used with single-purpose main-batteries, on cruisers and battleships, to measure only range and bearing to solve the fire control problem. Bearing

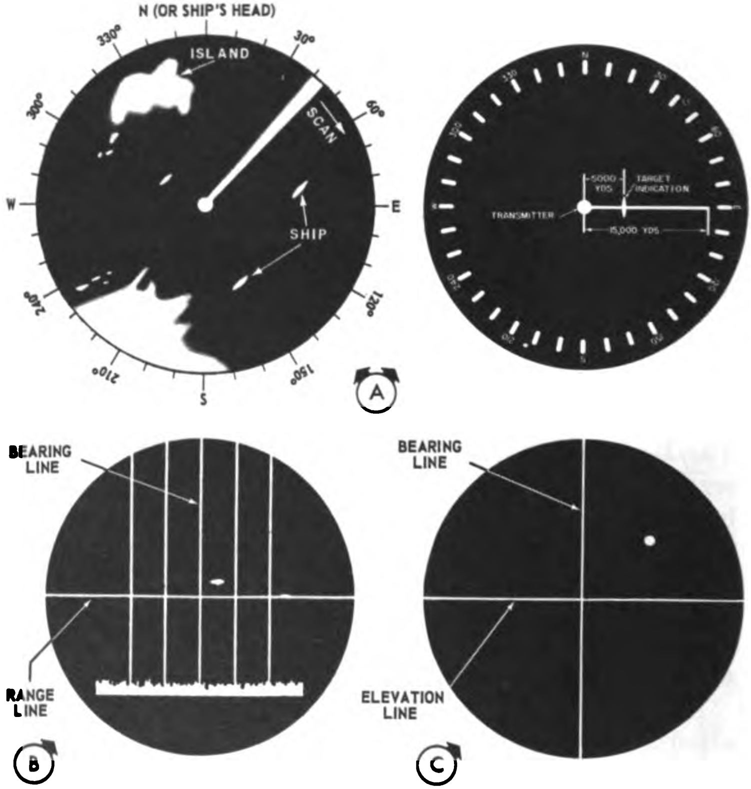


Figure 4-6.—Other types of radar presentation. A. PPI-scope. B. B-scope. C. T&E-scope.

is determined by use of the lobe-scanning principle and a B-scope presentation. The beam is moved horizontally by oscillating the antenna rapidly through a small angle. When on target, the antenna points at the target in the middle of its arc and the pip is bisected by the vertical line in the center of the scope. Range is measured by positioning the movable horizontal range line until it is tangent to the bottom of the pip.

Antiaircraft fire control radar, besides supplying range and bearing, must also furnish target elevation. Range is normally read from an A-scope. For bearing and elevation, the radars employ either SCANNING or LOBE-SWITCHING.

In scanning, the beam is rotated in a conical pattern about the antenna axis, and a T&E-scope presentation is used. The antenna is trained and elevated until the target pip appears exactly in the center of the scope.

In lobe-switching, the beam is transmitted "right-down-left-up" around the antenna axis. The right and left beams cause two pips to appear on the trainer's scope, while the down and up beams cause pips on the pointer's (elevation) scope. When the two pips on the scope are of the same height, the antenna axis is on the target in train or elevation. (Fig. 4–5, *B*.)

Radar reflections, whatever else they may indicate, don't identify the target as friendly or enemy. But friendly targets can be equipped with a special transmitter which functions when triggered by radar signals. This IFF (Identification Friend or Foe) unit sends out a coded signal for identification.

Though radar can "see" through fog and heavy weather, it can, like all other radio equipment, be JAMMED, either by hostile transmissions that interfere with the echoes, or by "false targets" set up by the enemy in the form of WINDOW—strips of metal foil, or paper strips with a metal coating. You know that some of your gun projectiles and rockets are loaded with window; it can also be dropped from aircraft.

FIRE CONTROL SYSTEMS

Gun fire control systems are adapted to the problems they solve, and, broadly, the general kinds of systems are parallel to the general kinds of problems. Thus, we can lump all surface systems under one heading, all dual-purpose systems under another, and all AA systems (though there are several major types) under a third. In the discussions here, we cannot take up the systems in the detail that a Fire Control Technician does. We shall concentrate only upon equipment on the gun mount.

MAIN-BATTERY FIRE CONTROL SYSTEMS

Although main-battery fire control systems of cruisers and battleships do not provide for control of fire at air targets (except for AA cruisers) they operate at such great ranges, and with such complex and physically massive gun and turret equipment, that they must include refinements that are not important in systems for lighter batteries. The main elements of a main-battery fire control system are located in four kinds of stations aboard ship:

1. The control station
2. The gun directors aloft
3. The plotting rooms
4. The turrets

The control station, known as the FIRE CONTROL TOWER, is the location from which the gunnery officer observes and supervises the operation of the ship's armament. Some ships have two control stations, one forward and one aft. These stations are often equipped with auxiliary gun directors, computers, radars, and stable elements, and can function in place of the director or plotting room in case of casualty.

All battleships and cruisers have two aloft gun directors for the main battery, equipped with rangefinder and radar. The forward director is always the ship's primary spotting station.

Main-battery plotting rooms are located below the waterline and inside the armor belt. They contain rangekeepers, stable vertical units, some units of the radar equipment, a fire control switchboard (for shifting control of various gun mounts and turrets among directors and other control points, or for divided fire), and a battle telephone switchboard associated with it. Battleships and *Salem* and *Worcester* class cruisers have some plotting room equipment duplicated elsewhere on the ship; other types make other provisions for divided fire and operation in case of casualty.

Figure 4–7 shows most of the equipment concerned with fire control in a main-battery turret of a typical modern cruiser (*Baltimore* class).

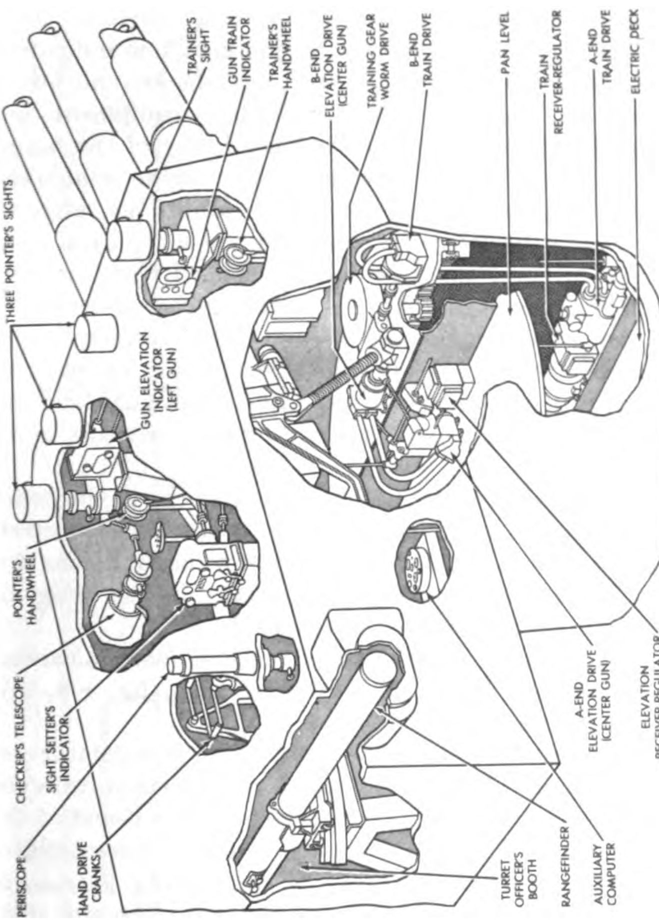


Figure 4-7.—Main-battery turret: Cutaway view, showing equipment important in fire control.

On the shelf plate at the rear is the turret officer's booth. This space contains the rangefinder and the rangefinder stabilizer, the spotter's periscope, auxiliary computer, multiple turret train indicators (MTTI's) and various switches and indicating lights. Forward are four sight stations, one on each outboard side of the turret and two between the guns.

The right station contains the trainer's periscope and handwheels, and the train indicator. The other three stations contain the periscopes, handwheels, and elevation indicators for three pointers (one for each gun). At the extreme left is the checker's telescope. The shelf-plate equipment enables the turret to be operated independently of the main-battery rangekeeper and directors. The sights enable the target to be located; the rangefinder measures the range to the target; and the computer solves the fire control problem.

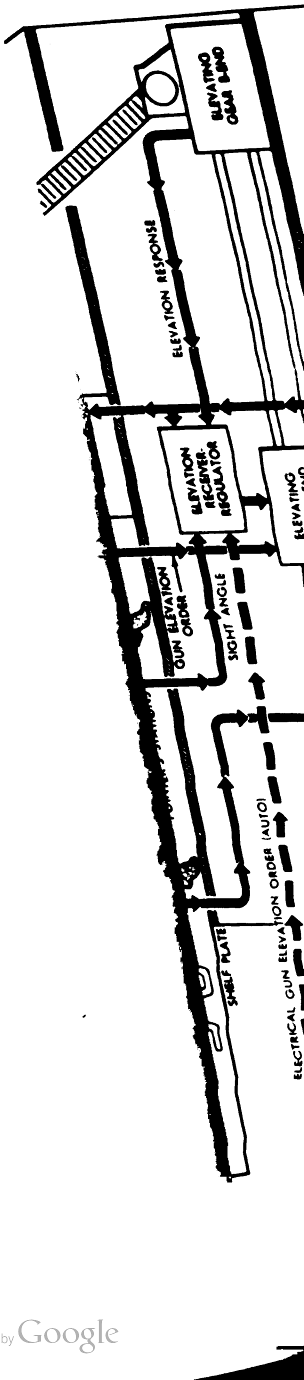
On the pan floor, one deck below the shelf plate, are the elevation receiver-regulators, the elevating-gear A-ends and B-ends, and the training-gear B-end. The receiver-regulators control the elevation of the guns (which operate independently in elevation) in response to the gun elevation order (auto and local), and the elevating gears actually move the guns.

On the next lower deck, the electric deck, is the train receiver-regulator, which controls the training of the turret, and the training-gear A-end. Emergency hand cranks for training and elevating the guns manually in the event of power failure are mounted on the shelf plate.

Now let us see how this equipment functions in various types of control. We'll take up train first (fig. 4–8, *A*); then elevation (fig. 4–8, *B*).

In AUTOMATIC CONTROL, the train receiver-regulator receives gun train order and unit parallax correction from the computer, and turret train response from the B-end of the training gear. With these inputs, the receiver-regulator automatically controls the A-end of the training gear so as to bring the turret to the ordered position. The gun train indicator transmits corrected turret train to the multiple turret train indicators throughout the system.

In INDICATING CONTROL (that is, with data received from the plotting room, but with the turret crew matching pointers to lay the guns) the trainer trains the turret in accordance with orders received from Plot by cranking his handwheels to keep gun train as shown in his gun train indicator matched with the indicated gun order shown in the instrument. The


ELEVATING GEAR BAND
ELEVATION RESPONSE
ELEVATION RECEIVER-REGULATOR
ELEVATING
GUN ELEVATION ORDER
SIGHT ANGLE
POINTER'S STATIONS
SHELF PLATE
ELECTRICAL GUN ELEVATION ORDER (AUTO)

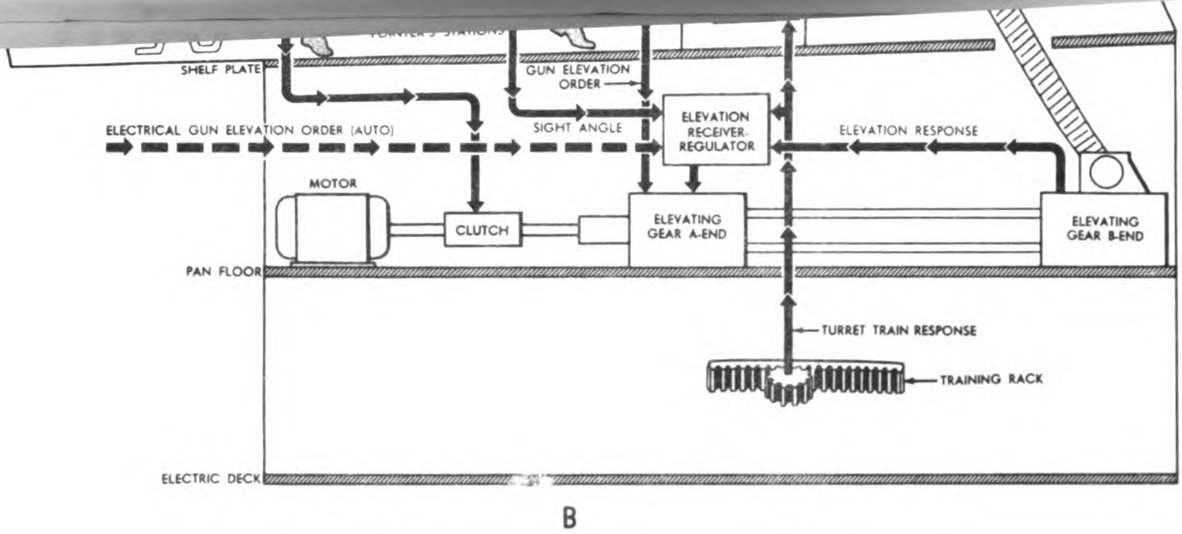


Figure 4-8.—Turret drive system (*Baltimore* class CA).
A. Train. B. Elevation.

Th
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gun train indicator corrects turret train response for parallax. The trainer's handwheels train the turret when the power drive is functioning either by a mechanical input to the receiver-regulator (as in LOCAL POWER) or by positioning the A-end tilt plate (HAND). In general, local and hand drive work much as they are described in connection with 5″/38 mounts in earlier courses in this series. For specific details on the individual types of turrets that you may work with, see the proper OP.

In LOCAL control, the target is located by the man at the turret periscope (usually the turret officer), and the turret trains until the target is in the turret sights. Range, as determined by the rangefinder, and turret train are set into the computer by hand; the computer uses this plus other data to give sight deflection, which is transmitted to the sightsetter by phone. He cranks it in, and the trainer operates his handwheels to keep his vertical crosshair on target. Naturally, no horizontal parallax correction is required.

If power fails, the turret can be trained in MANUAL (though at slow rates) by hand cranks that rotate the A-end directly through a clutch. The trainer's handwheels control A-end operation as in HAND control.

Now let's take up elevation. (Fig. 4–8, *B*.) The elevating equipment is similar in fundamental principles and functioning to the train equipment. It consists of the pointers' handwheels, gun elevation indicators, elevation receiver-regulators, and the elevating speed-gear A-ends and B-ends. Each of the guns is elevated independently by its elevating gear, which is controlled either by the elevation receiver-regulator or by the pointers' handwheels, depending on the method of gun laying employed. The handwheels may be connected through a clutch to the tilting plate of the elevating gear A-end, or to the receiver-regulator. The pointer operates his handwheels either to bring the horizontal crosshair of his telescope on the target, or to match dials on the gun elevation indicator.

Before gun elevation response is compared with gun elevation order, two corrections are made to the response signal WITHIN the indicator. These are (1) roller-path tilt correction and (2) erosion correction.

You have learned in earlier courses in this series why correction for roller path tilt is necessary. (If you're rusty on it, brush up on it before reading chapter 12, in which the functioning and adjustment of the roller path compensation device is taken up.) As for the erosion corrector, it compensates (by slightly increasing gun elevation response to make up for initial velocity loss) because of bore erosion. The amount of compensation is set into each gun elevation indicator by a hand-operated knob.

The elevation receiver-regulator, which controls the elevation power drive's A-end, also has a roller-path compensator and an erosion corrector, plus a mechanism to compensate for the characteristics of the elevating screw mechanism.

This last deserves some explanation. Look closely at figure 4–8, *B*, and imagine the relationship between elevating screw and gun barrel at the extremes of elevation and depression. The maximum elevation possible for this turret is about 41°. At this elevation, the elevating screw and gun barrel are approximately at right angles. Obviously, one turn of the elevating nut (driven by the elevation B-end) will move the gun barrel through a greater angle than it will at extreme depression. But a gun elevation order calling for, let us say, 10° change in elevation, will be the same whether the gun is at 0° elevation, 41° elevation, or any other position. It is clear, then, that more elevating nut rotation is required at some elevations than at others to produce the same change in elevation.

Note, by the way, that this elevating screw correction is not required in the elevation indicator, because mechanical response to the indicator (and to the pointer's periscope) comes off an elevating arc through a pinion. The elevating arc is NOT used for driving the gun in elevation. Elevation response to the elevation receiver-regulator comes from the power drive B-end.

Controls at each gun captain's and pointer's station which work hydraulic valves in the regulator are used to bring each gun quickly to loading position and, after loading, back to gun order position. The pointer's controls are usually set to permit this operation to be controlled by the gun captain's ready switch.

LINEAR-RATE FIRE CONTROL SYSTEMS

All fire control systems used against air targets (whether they are classed as dual-purpose or AA systems) can be divided into two main groups—LINEAR-RATE and ANGULAR-RATE. Linear-rate systems determine rates of change of relative target motion as linear rates (knots). Angular-rate systems measure angular velocities (degrees per second) of the line of sight by gyroscopic means.

Linear-rate systems at present are used mainly for heavier dual-purpose and AA armament, though they can be cross-connected to control machine guns. The most common system of this type now in the Fleet is the Mk 37, equipped with Mk 25 radar, installed on destroyers, cruisers, carriers, battleships, and some types of large auxiliaries. It is used principally to control 5″ batteries, though it can control others when so connected.

The Mk 37 system has already been discussed in some detail in earlier courses of this series. As you know, there are three major units in this system—the Mk 37 director aloft, the Mk 1 or Mk 1A computer; and the Mk 6 stable element. On many ships, the Mk 37 director can control part or all of the heavy machine-gun battery, while on cruisers and battleships (on which two or more Mk 37 systems control the dual-purpose battery) the Mk 37 director can supply director train and director elevation to the main-battery rangekeeper. The system (including computer and stable element) can also be connected to control the main-battery turrets directly (rather than through the rangekeeper) for AA fire.

With Mk 25 radar, the Mk 37 system can be LOCKED ON the target electronically to give fully automatic tracking, and the fire control problem can be solved by the Mk 1A computer in 4 to 6 seconds.

For further details on the individual units of the system and on the functioning of the system as a whole, see volume 1 (NavPers 10158–A) of the Navy training course for Gunner's Mate 3. See figure 4–2 for a schematic of the Mk 37 system.

RELATIVE-RATE FIRE CONTROL SYSTEMS

To grasp the requirements that the relative-rate system is supposed to comply with, we shall first glance briefly at the two most important factors of the fire control problem it is supposed to solve.

The two important angles to know in aiming a gun to hit a moving air target are LEAD ANGLE and SUPERELEVATION. You're concerned with lead angle because your target is MOVING, and because it takes time for the projectile you're firing to get to the target. So you fire at a point ahead of the target which your projectile will reach just as the target gets there. All this is old stuff to you; if you think you need to, brush up on it in volume 1 (NavPers 10158–A) of the Navy training course for Gunner's Mate 3.

You're concerned with superelevation because you are firing at an AIR target. In one respect, superelevation resembles sight angle; it increases with range. (Fig. 4–9, *A*.) (In fact, for targets on the surface you need make no distinction between sight angles and superelevation.) But superelevation DECREASES with target elevation (assuming the range to be constant). This is clearly shown in figure 4–9, *B*.

What other factors affect the design and use of any fire control system intended to control AA machine guns?

First of all, machine guns are all relatively short-range weapons. Second, aircraft are fast-moving, and are getting faster all the time. (These two factors, combined, mean that the problem must be solved FAST.) Third, the fire control equipment associated with machine guns is severely limited in size and complexity, because each individual weapon or group of weapons must be independently controlled—and

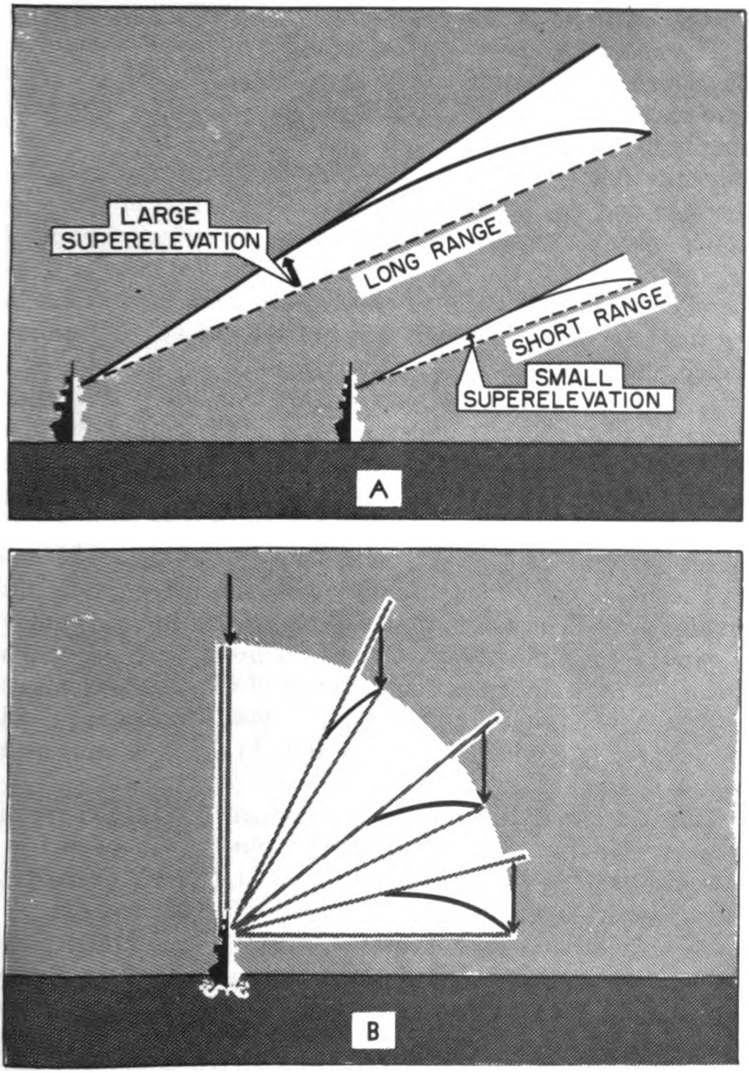


Figure 4-9.—Superelevation in the AA fire control problem. A. Superelevation increases with range. B. Superelevation decreases with elevation angle.

that means a number of small independent systems, rather than one or two big ones. Fortunately, the short ranges also mean that many refinements that must be used to arrive at reliable solutions in longer-range batteries can be neglected.

The relative-rate or lead computing systems that were developed to meet this combination of conditions measure rate of change of bearing and elevation as angular quantities simply by tracking the target. Most of these systems combine the functions accomplished in linear-rate systems by director and computer in one unit. (The function of the stable element plays no part in relative-rate systems.) In these systems, the sight case moves with and is always parallel to the gun bore; the line of sight is offset optically by the amount of lead angle and superelevation. These are called DISTURBED LINE-OF-SIGHT systems.

A few relative-rate systems are designed to track their targets and transmit angular rates to a separate computer that makes up gun orders. In these systems, which are called UNDISTURBED LINE-OF-SIGHT systems, the line of sight remains parallel to the sight case, and the gun barrels are offset by gun order.

The heart of every type of lead computing sight is the GYROSCOPE. You know that a gyroscope is fundamentally a rapidly rotating wheel. One of its important properties (which is the main operating principle of the stable element) is that it tends rigidly to maintain its position in space, and if mounted in gimbals, it will continue to do so as long as it keeps rotating.

But in figure 4–10 you see what happens when you try to push a spinning gyro around. The gyro does, of course, resist any attempt at shifting it, but when it yields, it doesn't just give way and permit itself to be pushed. It PRECESSES—that is, the wheel's axis of rotation tilts. (The movement is a lot easier to visualize than to describe, so look at figure 4–10, *B*, to see how it works.) If we equip the gyro with restraining springs that tend to return it to zero (upright) position, the amount of tilt will be proportional to the rate of turn (or angular velocity) of the gyro frame, and the

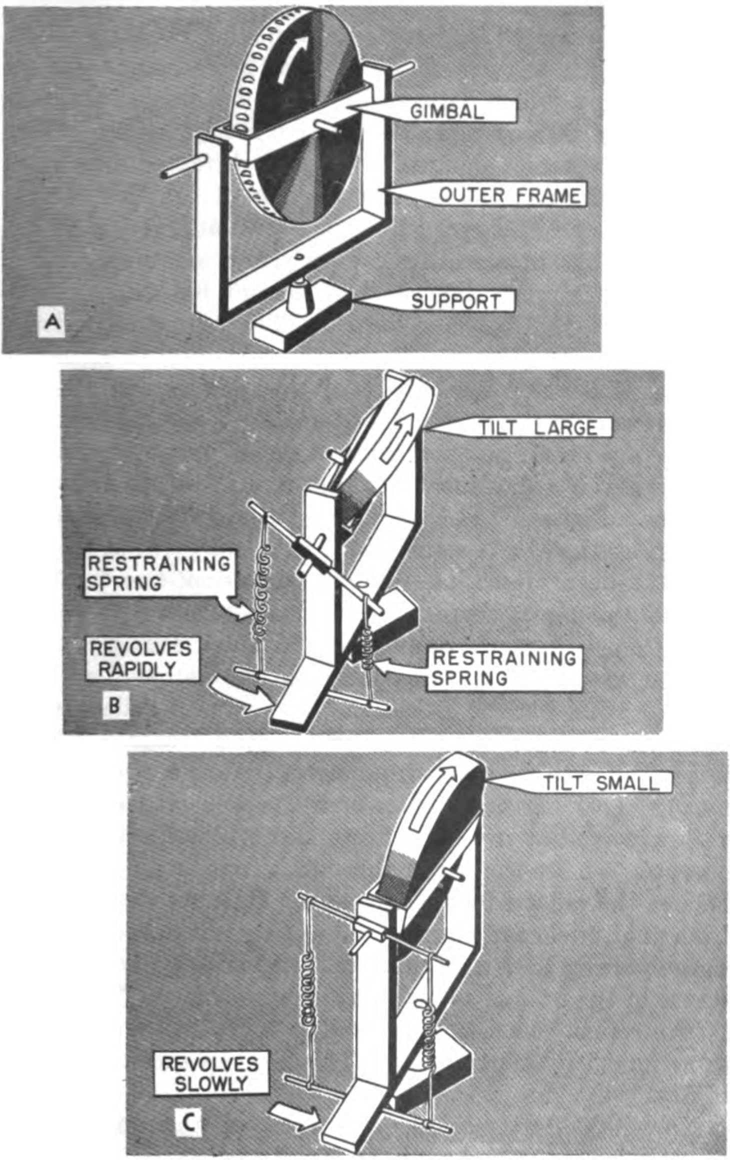


Figure 4–10.—Gyroscopic action in lead computing sight.

springs will right the gyro when the turning movement ceases.

Now the required lead angle for a moving air target is the product of the angular velocity of the line of sight and the time of flight (which depends on range and initial velocity). Suppose we use a gyro like this to give us lead angle. When we track the target smoothly, the gimbal frame turns about the input shaft at the angular velocity of the line of sight to the target. The gyro tilts. Next, we adjust the tension of the springs in accordance with the projectile's time of flight to the target. (We slack off tension for longer ranges, and increase it for nearer targets. The adjustment device can be calibrated in terms of range, and the range is estimated by eye.) Result: the output of this device will then be proportional to the required lead angle.

We have been discussing "line of sight," but where are the optical parts? The answer to that is that it's all done with mirrors. Figure 4–11, *A*, shows in schematic form the optical system for the Mk 14 sight, which uses two gyros of the type we have been discussing—one for elevation, one for train. Each of them is mechanically linked to a mirror. A beam of light from a RETICLE LAMP passes through a RETICLE (the pattern used here is two concentric circles) and a COLLIMATING TUBE (which makes the light rays parallel) to the TRAIN MIRROR (linked to the train gyro, of course). Thence it is reflected to the ELEVATION mirror (linked to the elevation gyro). This mirror is noteworthy because it's silvered in such a way that it both reflects and transmits light. The operator can see the target through it, but at the same time he sees the reflected reticle pattern. Because the light rays from the reticle are parallel, the reticle image seems to the sight operator to be at an infinite distance away, and parallax errors in the optical systems are eliminated.

The reticle can also be shifted in elevation and train (in some mods) by SPOT KNOBS. This permits quick correction of fire.

Now let's start tracking a target. As the train gyro is displaced, it rotates the mirror slightly (the amount depend-

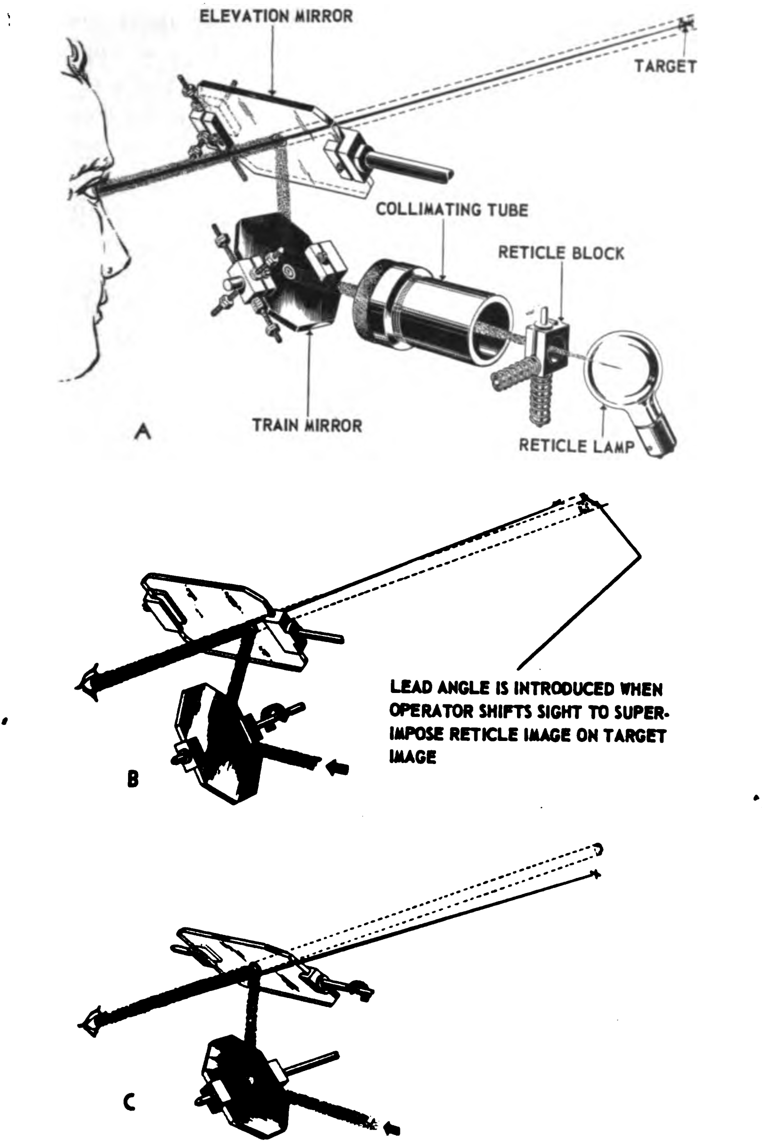

ELEVATION MIRROR
TARGET
COLLIMATING TUBE
RETICLE BLOCK
A
TRAIN MIRROR
RETICLE LAMP
LEAD ANGLE IS INTRODUCED WHEN OPERATOR SHIFTS SIGHT TO SUPERIMPOSE RETICLE IMAGE ON TARGET IMAGE
B
C

Figure 4-11.—Lead computing sight. A. Optical system. (Schematic.) B, C. Functioning of the optical system.

ing on the rate of train). This moves the light beam of the reticle lamp so that the apparent location of the reticle image in space (as seen by the sight operator) shifts in train. (Fig. 4–11, *B*.) The sight operator, of course, as he continues to track the target smoothly, shifts the sight to keep the reticle image superimposed on the target image, and thus introduces the proper component of lead angle in train.

Pretty much the same thing happens with regard to the elevation component of lead angle, except that the elevation mirror (fig. 4–11, *C*) does not affect the transmitted image of the target as it shifts the reflected image of the reticle. The operator's eye sees the sum of the two shifts (elevation plus train).

All this is fine for lead angle, but what about superelevation? Superelevation is introduced by balance weights linked to the gyro gimbals. Because of the linkage, the amount of superelevation correction varies (as we have seen that it should) with sight elevation. (Fig. 4–9, *B*.)

As we have seen, it is necessary to adjust the tension of the springs that limit gyro movement in accordance with estimated range. This is done by a range setter who estimates the range, and adjusts the springs by means of a calibrated knob. Since the springs and the balance weights act on the same linkage to the mirrors, this also takes care of variations in superelevation required by variations in range. (Fig. 4–9, *A*.)

NOTE: The gunner or pointer need not and MUST NOT attempt to lead the target when using a lead computing sight like the Mk 14 (or the Mks 15, 20, or 29). He must keep the reticle on target, and let the sight do the rest.

The lead computing sight system we have discussed in the above paragraphs is substantially the one used in the Mk 14 sight. These principles apply, in modified form, to later types of lead computing sights.

Mk 20 Lead Computing Sight

The Mk 20 sight, which is replacing the Mk 14 on 20 mm gun mounts, uses one electrically driven gyro (in place of the

Mk 14's two air-driven gyros), is lighter in weight than the Mk 14, and requires a much shorter "warm-up" period than the Mk 14. Like the Mk 14, the Mk 20 uses measured torques to cause gyroscopic precession in an amount directly proportional to lead angle, except that with the Mk 20's one gyro, lead angle is put out as one quantity. But the main force that induces precession is exerted by the action of a strong magnetic field (produced by an electromagnet called the RANGE MAGNET) on a copper EDDY-CURRENT DISC (so called even though it's shaped more like a bowl) on the gyro shaft. (Fig. 4–12.) As you remember from the chapter on electricity in this course (and from studying other courses on electricity), if you move a conductor in a magnetic field, a current is induced in the conductor. Moreover, the magnetic field of the induced current OPPOSES the movement that produces the current. In short, the range magnet exerts a drag on the gyro's rotation. When magnet and disc are lined up, the drag is concentrated on the center of rotation.

But as the sight case is moved in tracking the target, the magnet moves away from the center of rotation, and so does its drag. The faster the rate of tracking, the further from the disc's center does the magnet move. This causes the gyro to precess. It follows the magnet, but lags behind it. The further the magnet moves from the center, the greater the precessing force, and the greater the angle of lag. (This explanation neglects some of the subtler interplay of magnetic and mechanical forces, but it gives the general idea.) Or, in short, direction of angle of lag depends on direction of sight case movement, and its magnitude depends on the rate of sight case movement.

Gyro lag can also be controlled by changing the range magnet's current. More current gives a stronger field, with greater precessing force and smaller lag.

As you remember, lead angle depends on two factors—angular tracking rate and time of flight (range). Since gyro lag depends on two factors—rate of sight case movement (angular tracking rate) and magnet current, all we have to do is make magnet current proportional to range (by varying it with a calibrated rheostat) and we have made gyro lag dependent on the same factors as lead angle is. By proper design of the eddy current disc and magnetic structure, we can make gyro lag exactly proportional to lead angle—and we have a lead computing sight.

In the Mk 20 sight, superelevation correction is made in much the same way as in the Mk 14—by a weight linked mechanically to the gyro gimbal. Some mods of the Mk 20

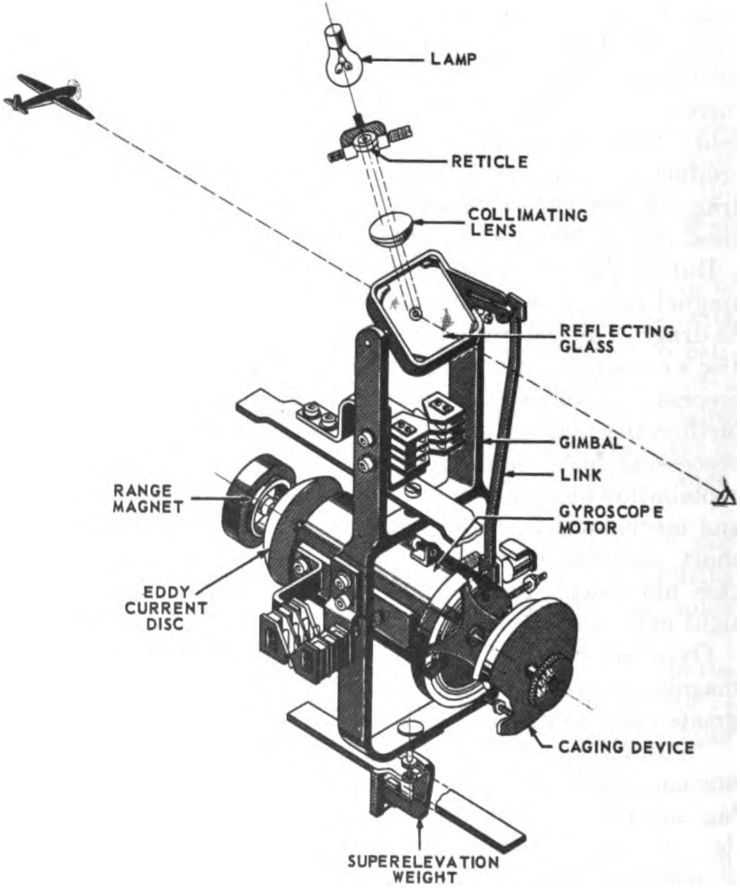


Figure 4–12.—Gun sight Mk 20. (Schematic.)

have spot knobs for shifting the reticle to introduce spotting corrections. A caging device holds the gyro to prevent oscillations until it is up to speed. And a slewing switch interrupts the normal gyro action when the operator is slewing the sight rapidly to a new target. This prevents setting up a large false lead angle.

As you can see in figure 4–12, the optical system of the Mk 20 sight is not unlike that of the Mk 14, except that it is simpler, requiring but one mirror.

Mk 51 Director

Because the lead computing sight actually solves the fire control problem at medium and short ranges, it can be made to perform the functions of both the computer and the director in a fire control system directing the fire of a number of guns. The first fire control system of this type consisted of the Mk 51 director mounting a Mk 14 sight. In this system, two men man the director—a POINTER who tracks the target just as he would if the sight were installed on a 20 mm gun mount, and a RANGE SETTER who estimates and sets the range, and acts as spotter, introducing corrections by adjusting range or operating spot knobs (if the sight is equipped with them) to shift the reticle position for correction of large errors in alignment.

With the Mk 14 sight functioning as both director and computer, the only function left is to transmit its output to the guns it is controlling. That is about all the Mk 51 director is designed to do. It consists of a pedestal secured to the deck; on this is a head that can rotate in train, and on the head is a carriage (on which the sight is mounted) that can elevate or depress. Coupled to the head and carriage are, respectively, pairs (one fine, one coarse) of train and elevation synchro transmitters (four synchros in all), and dampers which keep the tracking relatively smooth. The synchro transmitters put out gun order to the gun power drives. The train synchros are 1- and 36-speed; the elevation synchros are 2- and 36-speed.

The Mk 51 director (now with Mk 20 sight) is usually used with 40 mm and 3″/50 guns, though it can be connected to control larger weapons. Since there is no provision for parallax correction, all gun mounts under its control must be nearby to minimize parallax error.

Mk 15 and Mk 29 Sights

The Mk 51 system has been so successful that the Mk 15 and Mk 29 lead computing sights have been developed for use in more elaborate systems controlling larger guns.

In general, the Mk 15 sight resembles the Mk 14. It has two gyros—one for train, one for elevation—but they are heavier and more stable. It has a telescope for targets at longer ranges. (The Mk 14 hasn't.) It has provision for corrections for drift, wind, and variations in initial velocity. The optical system is different also in that the target image, rather than the reticle image, is shifted for superelevation and lead angle corrections. Lastly, the optical system in some mods of the Mk 15 is arranged so that the operator can view his target either in the conventional way, by looking at its image in the sight window, or by its presentation on the face of a radar cathode-ray tube.

The Mk 29 is similar to the Mk 15, but with improvements to permit it to deal with higher-speed targets. Both are used with all the MANUALLY OPERATED gun fire control systems discussed below.

Now let us take up very briefly the fire control systems in which these sights are used. These are all highly complex systems, and we cannot go into any detail, but from what you have learned in this chapter you see how important the lead computing sight is in all of them.

Gun Fire Control System Mk 52

Gun fire control system (GFCS) Mk 52 (figure 4–13) is designed for controlling 3″/50 and 5″/38 guns on small combat ships, landing ships, fleet auxiliaries, and Coast Guard vessels. Its output to gun mounts (including gun order, fuze setting order, and train parallax) takes into account not only the motion of ship and target, supereleva-

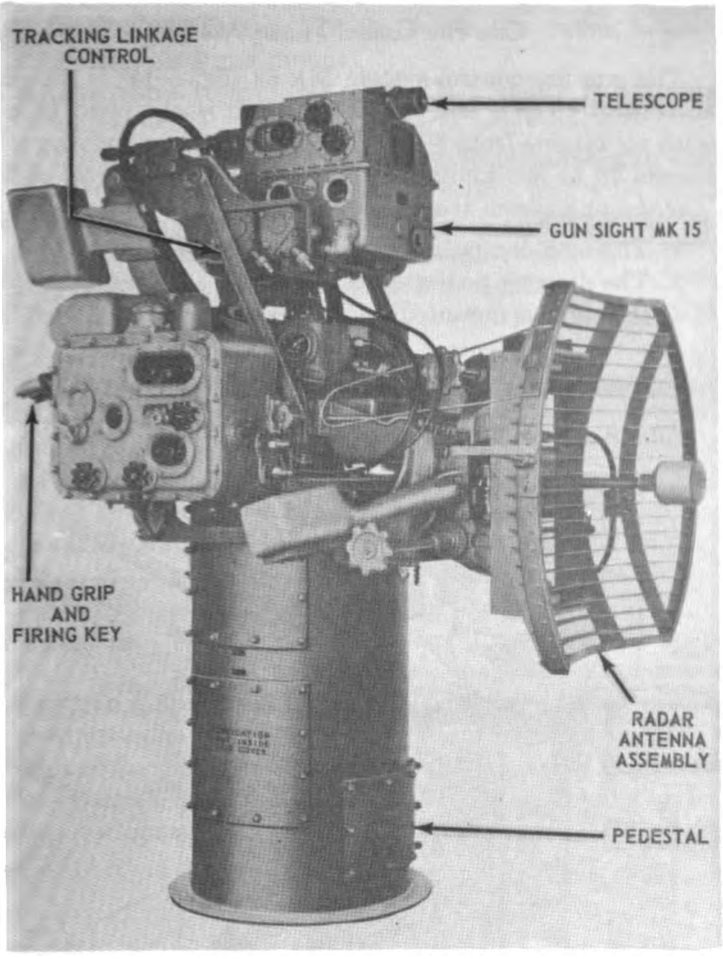


Figure 4–13.—Mk 15 sight installed on Mk 52 director.

tion, and drift, (all of which are worked out automatically by the Mk 15 sight which is part of the system) but also changes in initial velocity, wind, and horizontal parallax. It is radar-equipped, and is manually trained and elevated. It functions as a disturbed line of sight system for air targets, though it can be used as an undisturbed line of sight system against surface targets at extreme ranges.

Gun Fire Control System Mk 63

The gun fire control system Mk 63 (fig. 4–14) is designed to control 40 mm and 3"/50 guns and is equipped to deal with air targets from 800 to 7,000 yards range, moving with speeds up to 800 knots (when fitted with the Mk 29 sight). The major units in the system are:

1. The lead computing sight Mk 15 or Mk 29.
2. The director pedestal Mk 51 or Mk 1 Mod 0 (on which the sight is mounted).

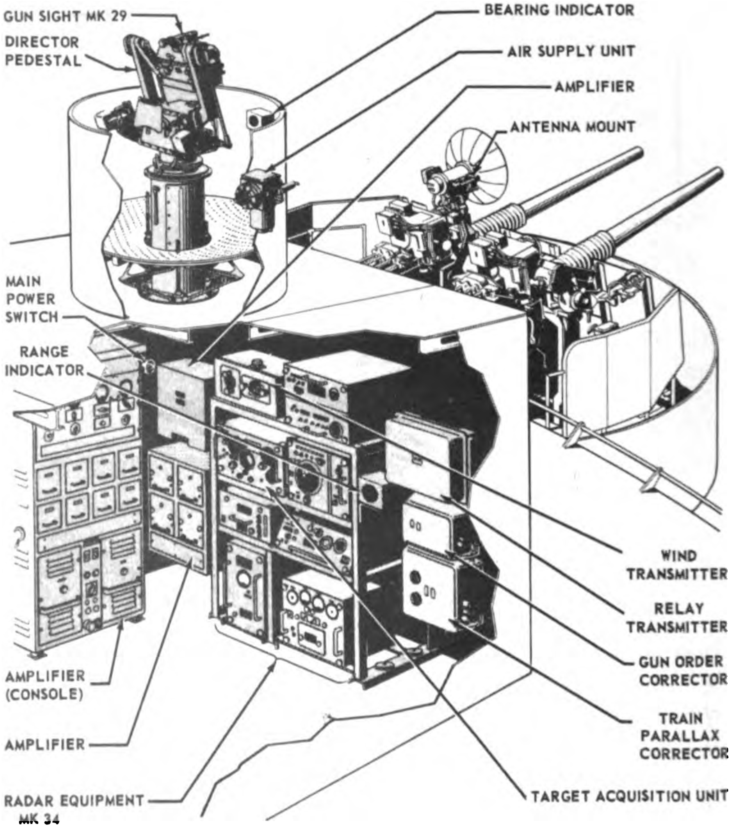


Figure 4–14.—GFCS Mk 63. Major units.

3. Radar equipment Mk 34 (with the radar antenna located on a gun mount).
4. The wind transmitter. This is actually a computer which works out and introduces wind correction into the system. Its inputs are own ship course, gun train order, own ship speed, wind direction, and wind speed.
5. Target acquisition unit (TACU). This unit aids the sight pointer in locating the target when visibility is poor or there are many targets in sight.

The director operator tracks the target manually by training and elevating the lead computing sight on the director and keeping the target image centered in the reticle. The lead angle generated by the sight is transmitted to the gun mount power drive, so that the guns will lead the target. Lead angle is also transmitted to the radar antenna's independent power drive on the gun mount, but here it is applied to cause the antenna axis to lag the gun bore axis by an angle equal to the lead angle. The result of this, of course, is that the radar antenna is always aimed at the target.

The director operator sees the target on the radar scope (T & E presentation) as a dot; the image is reflected onto the sight's eyepiece by mirrors. It is preferable to use the optical image in tracking, but by dimming the image with a filter and increasing the brightness of the radar scope, the sight operator can use the radar image if the target's optical image is obscured.

Gun Fire Control System Mk 57

GFCS Mk 57 (fig. 4–15) is designed to control the fire of 40 mm, 3-inch, 5-inch, and 6-inch AA or dual-purpose weapons at either visible or obscured targets, using either optical or radar tracking. This system has a manually operated gun director Mk 57 on which is mounted a telescope, but the telescope is a straight optical system without mirrors. Its movement in train and elevation as it tracks the target is transmitted to a computer Mk 17 in the director pedestal. This computer is nothing more than a lead computing sight minus optical parts. The lead angles are picked off the

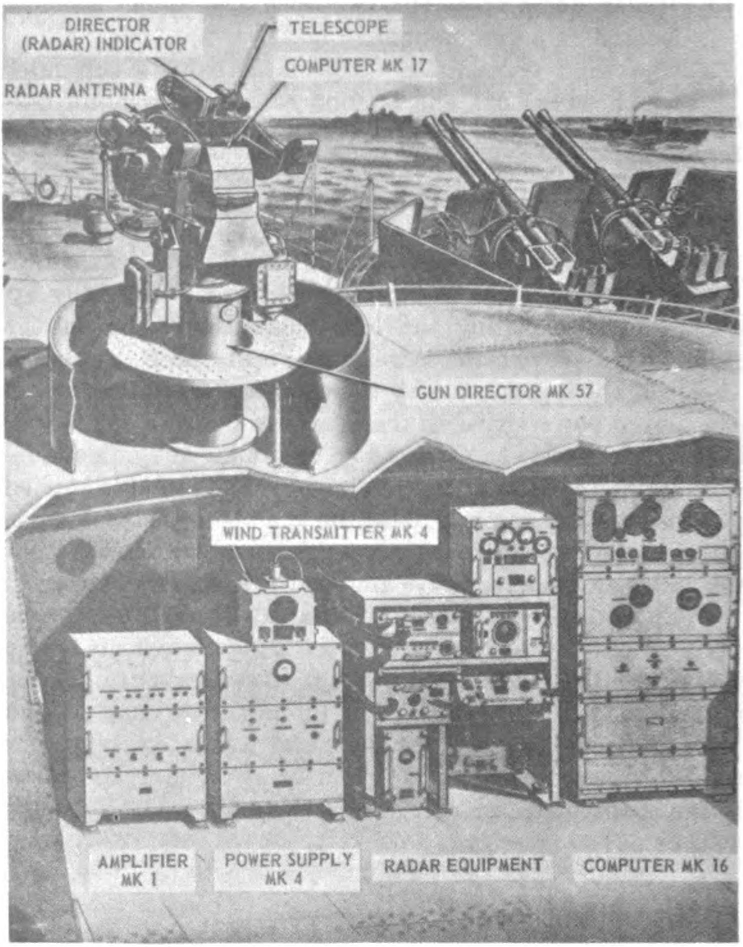


Figure 4–15.—GFCS Mk 57. Major units.

gyros in the computer and transmitted electrically to another computer (Mk 16) and a wind transmitter (Mk 4) below decks. Gun orders, including horizontal parallax correction if needed, go to the gun mounts by synchro transmission. Since the director's telescope is always right in the line of sight, the Mk 57 is an undisturbed line of sight system. The radar antenna is on the director head.

Gun Fire Control System Mk 56

You could make a good case for saying that GFCS Mk 56 is, if not the most complicated, one of the most advanced fire control systems in the business. It can track targets moving at up to 650 knots, and its director can train at up to 100° per second. It can solve the fire control problem after tracking for as briefly as 2 seconds. It is an intermediate range (up to 12,000 yards), AA undisturbed line of sight system which provides gun order (train and elevation) and fuze setting order for 3-inch, 5-inch, and 6-inch guns. It can also be used, of course, against surface targets. One unique feature of the system is that it can control two different batteries firing at the same target simultaneously, furnishing different gun orders for each battery. (This is called a DUAL-BALLISTIC system.)

The Mk 56 system is the only one of the relative-rate systems we have discussed in which the director is power operated (by an amplidyne system). Its radar antenna is mounted on the director, as with the Mk 57 system. Though the director operator can track targets by following them with a telescope, the director will track a target automatically, once it is locked on, by radar. The system measures range by radar, though estimated range can be put in manually by the director operator. The system has an elaborate network of computers, including a ballistic computer, a gun order converter (which converts the output of the first computer to suit the ballistics of another type of battery, if the system is controlling more than one), a wind transmitter, a train parallax corrector, and two control panels.

ANTISUBMARINE FIRE CONTROL

As you already know, the two major types of weapons used against submerged submarines from surface ships are DEPTH CHARGES and THROWN WEAPONS, which latter include rockets and hedgehog projectiles. We shall go into considerable detail on both depth charges and thrown weapons later in this course; in this section we shall briefly take up the process of detecting and locating underwater targets, and transmitting firing orders.

Sonar

Radar cannot be used under water, because water absorbs radio waves. But water does conduct sound—better than air does, in fact. And sound is what the Navy uses to detect underwater targets.

It is possible to detect a submarine operating under power by merely listening—with the aid of a suitable microphone. But present-day submarine detection equipment functions somewhat like radar—it emits a pulse of sound energy, then picks up echoes. The equipment is called SONAR—SOund NAvigation and Ranging—and it not only detects underwater targets, but also locates them in terms of range, bearing, and (in some newer equipment) depth. Let's see how sonar works on a small A/S vessel.

As you see in figure 4–16 the main units of the sonar equipment are a TRANSDUCER housed in a water-filled DOME or streamlined housing protruding from the ship's hull, and a STACK, manned by a Sonarman. The stack periodically produces a powerful pulse of alternating current, which is trans-

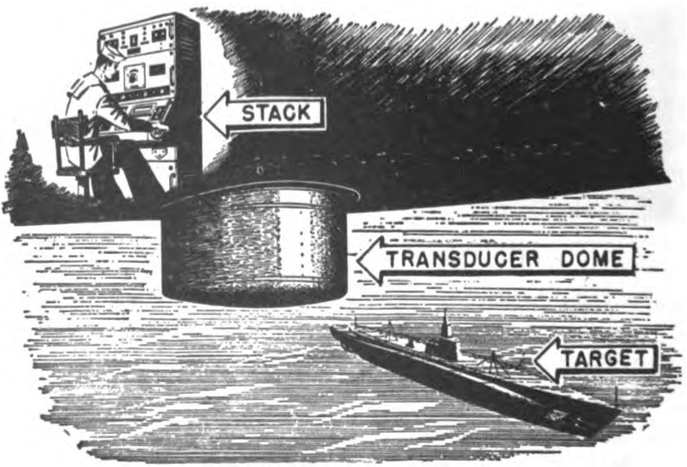


Figure 4–16.—Elements of sonar system.

mitted to the transducer. The transducer converts the current into a pulse of high-frequency sound (around 20,000 cycles per second), and projects it into the water along a fairly narrow beam. The transducer then switches to receive echoes, which are amplified in the stack. However, sound vibrations of 20,000 cycles per second are ULTRASONIC—too high in pitch to be audible to people of normal hearing. So the stack's electronic circuits convert the echo to an easily audible 800 cycles-per-second note, which is what the Sonarman hears over the stack's loudspeaker. Bearing can be read from a dial showing the transducer's bearing. Range is obtained from a timing device which measures the length of time it takes for the sound (traveling at about 4,800 f. p. s., depending on temperature and other factors) to reach the target, and the echo to get back to the ship; range is displayed on a scale calibrated in yards.

With smaller ships and older installations, the Sonarman manning the stack goes through a continuous search of the underwater area about the ship. He "pings" (sends out the high-frequency sound pulse), trains through 5°, and listens; pings, trains, listens, and so on through the entire arc of train, interrupting the process only to investigate echoes. Aboard larger ships that specialize in A/S attack, such as DDE's, the equipment is more elaborate. The transducer pings through 360°, and the indicator presents an image of sonar echoes as blips on the face of a cathode-ray tube (much as with radar PPI-scope presentation). These ships also have additional sonar equipment to determine depth of the target.

The data from the sonar stack goes to Underwater Battery Plot (usually called UB Plot), where the fire control problem is set up and solved.

A/S Attack with Depth Charges and Thrown Weapons

When a sonar contact has been made, the first procedure is to classify the contact as submarine or nonsubmarine. If the contact is a submarine, then contact must be maintained and the target attacked. If contact is lost in the course of the attack, it must be regained. This goes on as long as necessary.

However, there is one great difference between the fire control problem in gunnery and in A/S weapons. Whether depth charges or thrown weapons are used, the ship must be conned into the position from which the weapons can be used. This is true of ALL A/S weapons except the Mk 108 rocket launcher.

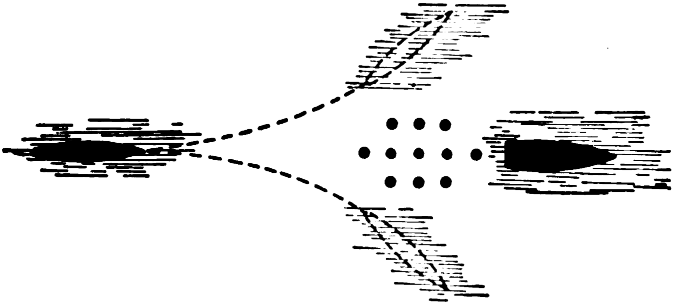
Let's take up depth charges first. These can, as you know, be dropped from launching tracks at the stern or be fired from K-guns as far as 125 yards on the beam. Because of the delays inherent in the use of this type of weapon, depth charges are rarely used singly; they are most often used in groups or PATTERNS of definite configuration, and those that can be set to explode at definite depths are adjusted so that the pattern is effective in depth as well as over an extended area. There are two major types of pattern—DIVERSIONARY and DESTRUCTIVE.

The diversionary pattern is laid to harass the sub and prevent accurate torpedo fire. It consists of one or more charges fired immediately, with shallow settings, in an attempt to drive the submarine down and prevent it from firing torpedoes. The diversionary charge may not damage the submarine. It is merely a defensive move to protect the escorted ships.

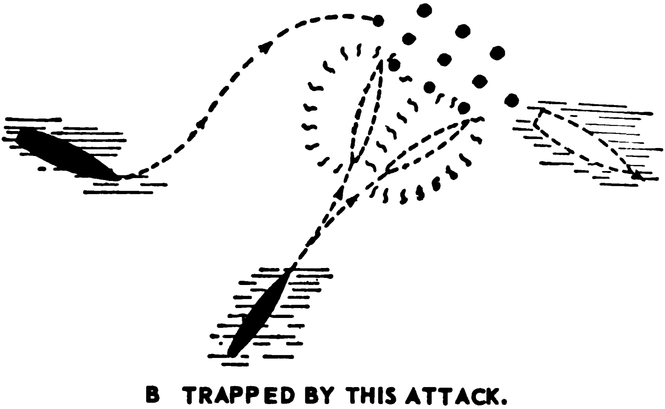
The purpose of a destructive attack, however, is just what the name indicates. The pattern is dropped in such a way that the center charge of the pattern will explode against the submarine. The destructive pattern is the standard full pattern of charges that is fired by the attacking vessels.

The chief difficulty with any attack is the time required for the charges to sink. The obsolescent 750-pound depth charge, for example, requires about 40 seconds to reach a depth of 250 feet. During this time the submarine can maneuver without interference. In 40 seconds an 8-knot submarine can travel 180 yards, make a 60° turn, and even change its depth by 60 feet.

If the sub is moving straight along the attacking ship path, it is a simple matter to compensate for the sinking time of the charges, and drop them so that the sub's course will bring it right into the midst of the pattern. But any sub skipper who is not a fool knows this. Sonarmen aboard the sub can hear the attacking ship, can plot its course, and avoid staying on its track. Figure 4–17, *A*, shows how the submarine can take evasive action. By following a somewhat more elaborate course, however, as shown in figure 4–17, *B*, you can see how the A/S vessel can so place the pattern that it is difficult for the sub to evade. And you



A SUBMARINE WILL EVADE THIS ATTACK.



B TRAPPED BY THIS ATTACK.

Figure 4–17.—Depth charge patterns.

can see why the conning of the ship is an important phase of A/S attack.

With thrown missiles, the sonar operator must hold contact with the sub and furnish the conning officer with continuous ranges and bearings. The conning officer then keeps the ship headed toward the target and comes in for the attack. Because the charges have a fixed range, the pattern must be fired when the ship reaches the correct firing range.

In brief summary, then, this is the procedure: After sonar control has located the target in range, bearing, and (if the sonar equipment permits) depth, the data are set into computing devices in UB Plot. The solution comes up in terms of the LOCATION where the depth charges or thrown missiles are to be dropped, and the TIME when they should be dropped. Conn maneuvers the ship into position for attack, and the command to fire goes to the throwing weapons battery or depth charge battery direct from UB Plot at the calculated time (plus or minus any correction factor that, in the judgment of the ASW officer, is required). Depth charges and throwing weapons are never used both at once. Sonar control then attempts to regain contact, and the attack may be repeated as necessary.

SPOTTING

In earlier courses of this series you have learned why spotting is required, and some of the basic concepts associated with spotting. As a Chief Gunner's Mate you may be called upon to take charge of a mount in local control, and your ability as a spotter will have a great deal to do with the mount's efficiency in demolishing its targets.

With smaller weapons, spotting is a process that every gunner deals with on his own. In general, the man who both aims and fires his gun does his own spotting. But with mounts having more elaborate sighting equipment, in which it takes more than one man to position the gun in train and elevation, to fire, to set fuzes, and to introduce sight corrections, the spotter has an important function. This is true even in the 20 mm mounts fitted with lead computing sights, where a range setter corrects the fire for the gunner. However, we shall, in this section, be more concerned with larger mounts, like the 5″, on which you may function as spotter in the course of your duties as mount captain.

Definitions

We'll devote our attention to optical spotting only. Radar spotting requires pretty thorough grounding in "pipology" and methods of radar presentation. When you act as spotter in local control, you will usually not have a radar instrument to work with. Let's review some definitions of concepts important in spotting. Some of these are illustrated in figure 4–18.

1. A **SALVO** consists of two or more shots fired at the same target, at the same time, on the same signal.
2. **POINT OF IMPACT** is the place where each shot hits the water, or the target.
3. **MEAN POINT OF IMPACT** (MPI) of a salvo is the point at the geometrical center of the points of impact of all the shots of a salvo (except wild shots).
4. **WILD SHOT** is a point of impact abnormally far from MPI. It is usually due to someone's error—such as failing to fire on signal.
5. **LINE OF FIRE** is the true bearing of the target from the battery at the instant a shot or salvo is fired.
6. **PATTERN** is the area covered by the points of impact of a salvo (except wild shots). The **PATTERN IN RANGE** is the distance, measured parallel to the line of fire, between the point of impact nearest to the battery and the one farthest away. The **PATTERN IN DEFLECTION** is the distance, measured at right angles to the line of fire, between the points of impact at the extreme right and left of the pattern.
7. **DISPERSION** of a specific shot is its distance from the MPI. When you average the dispersions in a salvo you have the **MEAN DISPERSION**.
8. A **MIL** is an angle (about 0.06 degree) which at any range subtends an arc one one-thousandth of the range.

(A target one yard in linear width, at a range of 1,000 yards, has an angular width of one mil.) It is used in measuring sight deflection only.

9. BRACKETING describes two successive salvos falling so that the target is between them. Bracketing may occur in either range or deflection.
10. STRADDLING describes the fall of one salvo so that the target is in the midst of the pattern.

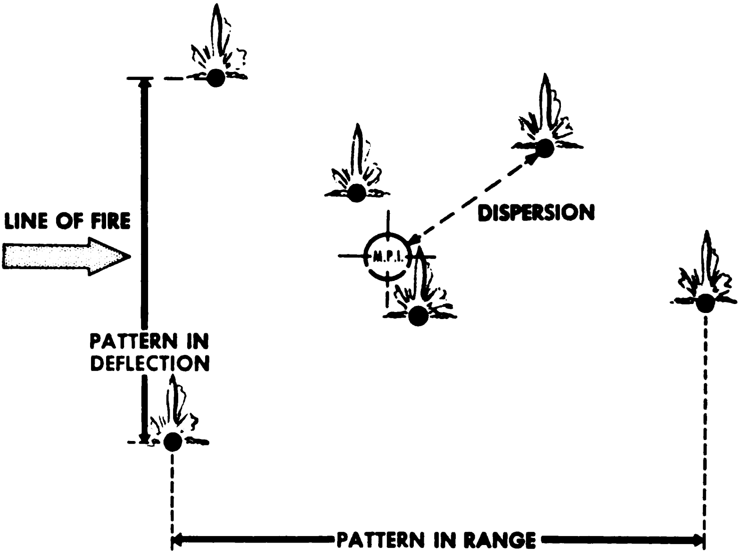


Figure 4-18.—Pattern of a salvo.

The Spotter's Duties

The spotter's duties for the main battery are set up in the ship's battle bill and fleet doctrinal publications. You are not likely to serve as the ship's spotter, but in many ways spotting for a 3-inch or 5-inch mount in local control is more or less a miniature of the main battery spotter's job. His main duty is to correct gun laying errors so as to get his gun fire to hit the target, but he has other duties, including the following:

1. Search for and locate the enemy.
2. Describe enemy forces (number of ships, bearing, etc.).
3. Estimate all values for the initial rangekeeper set-up (enemy speed, target angle, etc.).
4. Notify Plot and Control of changes in target angle, etc.
5. Keep Conn and Control informed of the tactical situation.

When you're acting as spotter for your own mount or sector, you'll be doing No. 1 at relatively short range, and you won't have much occasion to do No. 2 unless you're in communication with the AA officer and he asks for the information. You'll be doing a lot of No. 3 and No. 4, but you will not have a rangekeeper at your disposal and your information will be for the benefit of your own mount. That's why it is important for you to become expert at making quick, accurate range, bearing, and target speed estimates—and that takes practice. As for No. 5, you will be getting tactical information from your control officer, rather than the other way about.

To estimate target angle of surface targets at any considerable range, you should know the structural details of likely targets. Scale models and silhouettes should be available on all ships for study of such features, and you should study them for target angle estimation as well as for recognition. Estimation of air target speed requires experience—though it helps to have some knowledge of performance characteristics of typical enemy aircraft. The same goes for surface targets, though these also furnish cues to speed in the form of smoke from the stacks, bow wave, and wake. In estimating range of any target, you should have a good idea of the ACTUAL size of the target. Then, if you can find the size in mils, it isn't difficult to make a fairly accurate estimate of range.

Now let's get back to the spotter's main duty—seeing that the battery or gun mount is properly laid for hits. First you estimate, on the basis of observing the target, the range and target motion. Then you order a salvo fired at settings for these values, and observe how close the shots fall. On the basis of your estimates of error, you order corrections or SPOTS in range and deflection. And in doing that you use standardized expressions, as follows:

1. SURFACE TARGETS. For these, you spot only deflection and range, in that order. (If the first salvo is far off in deflection, you may find it impossible to adjust range until you have corrected in deflection.) For deflection correction you say "RIGHT (or LEFT) ______ MILS." For range correction you say "ADD (or DROP) ______ YARDS." Where no correction is necessary, you say "NO CHANGE."

NOTE: Always give spots in the SAME ORDER—first deflection, then range. If you want to order a spot in deflection and none in range, give your deflection spot, then say NO CHANGE for range. When you are on target, you order RAPID FIRE or whatever else is called for under the circumstances, in accordance with the requirements of standing orders or fleet doctrine.

2. AIR TARGETS. For air targets you make corrections in three dimensions, and you need them pretty fast. Even experienced men have a difficult time estimating errors rapidly in three dimensions. AA spotting is therefore not attempted very often, and then mostly to compensate for serious constant system errors. The proper terminology for spotting in the AA problem is:

Deflection correction—RIGHT or LEFT, in mils.

Height-of-burst correction—UP or DOWN, in mils.

Range correction—ADD or DROP, in yards.

In shore bombardment, as in AA fire, spots in three dimensions are often necessary. The terms are the same as those we have already mentioned, but the units are not the same. When naval guns support landing operations, joint forces are involved. The Navy, Army, Air Force, and all Allied forces have a standardized spotting terminology.

Methods of Spotting

The methods of spotting that are used aboard ship are prescribed in fleet tactical publications (such as NWP's and

ATP's), and you must conform to them. But it may be helpful to review the important methods of spotting here in a general way.

The DIRECT method is to order a spot equal to the estimated correction. This method is used by the main battery spotter at medium ranges, or if aircraft observations are used to estimate range spots, but otherwise its main use is in radar spotting.

The BRACKET-AND-HALVING method is used at long ranges by the main battery when no radar or aircraft spotting is available. When the splashes are in line with the target, the target is bracketed by firing one salvo short and then another that is sure to be over. The next spot halves the difference between the short and over salvos; the halving continues until the target is straddled, and then the battery shifts to continuous or rapid salvo fire.

The LADDER method is to open fire short, and increase range in steps larger than pattern size. When the target is bracketed, the range spot is halved and further adjusted until the target is straddled. This method is used where ranging is difficult and visibility is poor.

The BARRAGE method is to place a zone of fire short or over the target, so that the target will move into the zone as it maintains its course and speed. The barrage zone is shifted to keep the target in it. This method can be used by AA and dual-purpose batteries against fast-moving targets.

The TRACER method of control consists of spotting shots by noting the error as the tracer passes the target. It is used chiefly in spotting machine-gun fire. At longer ranges, tracers are of doubtful assistance to the spotter, because of the difficulty in keeping them in sight or in judging when they pass the target. Under certain light conditions the tracers cannot be seen clearly, and should not be relied upon except for short-range firing.

As you can see from the preceding discussion, the spotting techniques for surface targets are considerably better developed than those for air targets. One reason for this is that as the AA problem has become more important, radar has been developed and refined to so high an efficiency that in the newest fire control systems (for example, the Mk 56) radar has become the heart of the system, while even optical tracking (let alone spotting) has become secondary in importance.

However, visual spotting of air targets is by no means a lost art. The ring sight is a great help. Naturally, the ring sight cannot be as efficient as a lead computing sight, but it is still provided for emergency use on open mounts and at the mount captain's station on enclosed 5″ mounts, and with practice it is just as effective as it was before the improved sights were introduced into the Fleet. To correct your fire visually when using VT-fuzed ammunition, one technique is to fire every third or fourth round using time-fuzed AA projectiles, and spot by using air bursts. There are other wrinkles, too, in spotting AA fire. To pick these up, and in fact to keep up to date on the whole subject of spotting, keep abreast of the fleet tactical publications on your ship.

CONCLUSION

In this chapter we have taken up the aspects of fire control that are of some concern to you as a Chief Gunner's Mate. If you are interested in studying further in this subject, try *Naval Ordnance and Gunnery* (NavPers 10798), and the Navy training courses for Fire Control Technicians.

QUIZ

In each of the following, select the BEST answer.

1. In a radar system, the function of the cathode-ray tube is to
    - a. amplify the echo until it can be heard on the loudspeaker
    - b. show visually the transmitted pulse and radio echo
    - c. time the transmitter pulse
    - d. show a television picture of target at any range
2. Which one of the following radar presentations most closely resembles a view taken through the pointer's or trainer's telescope?
    - a. A
    - b. PPI
    - c. T&E
    - d. B

3. In the *Baltimore* class main-battery turret, elevation response to the elevation receiver-regulator comes from
    a. a pinion engaging the elevating arc
    b. the gear segment on the gun trunnion
    c. the elevating screw
    d. the elevating gear B-end
4. As target elevation angle increases, superelevation
    a. increases
    b. depends more on lead angle
    c. remains at a constant value
    d. decreases
5. In which of the following types of gun fire control system is the sight case ALWAYS parallel to the gun bore?
    a. Disturbed line of sight
    b. Undisturbed line of sight
    c. Relative-rate
    d. Linear-rate
6. In all lead computing sights, the operator keeps the guns correctly laid for hits by
    a. setting lead angle with the spot knob
    b. letting the target lead the reticle
    c. keeping the reticle on target
    d. letting the reticle lead the target
7. In the Mk 15 lead computing sight, corrections are introduced by offsetting the
    a. reticle image   c. sight case
    b. target image   d. radar tube
8. Which of the following relative rate systems has a power-driven director?
    a. Mk 51   c. Mk 56
    b. Mk 57   d. Mk 63
9. In sonar equipment, the ultrasonic sound pulse is projected into the water by the
    a. loudspeaker   c. stack
    b. depth charge projector   d. transducer
10. When one salvo is over the target, and the next is short, the target is said to be
    a. bracketed   c. spotted
    b. straddled   d. none of the above

CHAPTER 5

SMOKELESS POWDER

INTRODUCTION

In your career as a Gunner's Mate, you have had to deal with many types of ammunition, and you have gotten to know a good deal about it. Most of your experience has been with gun ammunition; this course will therefore not attempt to cover this ground, which you already know so well, except for one subject: smokeless powder. As the *Qualifications for Advancement in Rating* indicate, you have special responsibilities with respect to smokeless powder, and this chapter is intended to provide the detailed information on smokeless powder that you will need.

This chapter takes up gun ammunition propellants only. If you want to review other aspects of gun ammunition, see the earlier courses in this series and the other specialized technical texts on the subject. The best of these special sources for study are:

1. The *Bureau of Ordnance Manual*, as amended by applicable OCL's and other technical issues.
2. OP 4, *Ammunition*, as amended by current technical issues.
3. *Ammunition Handling*, NavPers 16194.

Other types of ammunition are discussed elsewhere in this book.

Background

Before smokeless powder was adopted for use in the United States Navy, black powder was the jack-of-all-trades in explosives. It served as propellant, igniter, bursting charge, and fuze. Black powder was used for all these purposes not because it was best suited for them, but because until well into the nineteenth century it was the only practical military explosive that anybody knew.

As a propellant, however, black powder left much to be desired. When it burned, its dense black smoke made a convenient aiming point for enemy fire; at the same time it impeded the gunner's vision. At night, its brilliant muzzle flash momentarily blinded the gun crew, and clearly showed the gun's location, so as to make it an easier target. Black powder's overfast burning rate—approaching high-order detonation—made it necessary to have excessively massive gun tubes with bulbous breeches to withstand its shattering impact; yet this same high burning rate reduced its total effectiveness as a propellant. After firing, it left quantities of solid residue fouling the bore; at the same time, its high burning temperature caused rapid erosion of the bore. And, though it was stable enough to last indefinitely if kept dry, it was sensitive and therefore difficult to store and handle safely.

As a propellant, smokeless powder is superior to black powder in most of these respects. It burns slowly enough to provide optimum thrust on the projectile, thus permitting higher muzzle velocities and much more economical gun designs; it causes less erosion and powder fouling; as its name implies, it produces less smoke (though it is not 100 percent "smokeless"); and it produces less muzzle flash. Besides, constant research is going on to improve it, especially with regard to flash, burning temperature, and stability.

Yet, with all these real advantages, smokeless powder is not the ideal propellant. Its introduction resulted in improved propellant performance, but it brought some new problems, most of them concerned with the fact that smokeless powder is essentially unstable. This is something that the old-time Gunner's Mate scarcely had to worry about. Black powder, provided it is kept dry, has almost unlimited stability, but smokeless powder contains an unstable substance that causes the powder to deteriorate in storage. This lack of stability creates problems in surveillance for the Gunner's Mate.

How Smokeless Powder Is Made

It will help you to understand why smokeless powder behaves as it does if you know something about what it is made of and how it is manufactured. It is not possible in this course to go into too much technical detail on its chemical composition and manufacture; the student is referred to OP 4, *Ammunition*, for that. The following is intended only as a brief summary.

The raw materials used in making smokeless powder are cellulose, nitric and sulfuric acids, ether, ethyl alcohol, and diphenylamine.

CELLULOSE is a plant product. It is the main ingredient in wood and in vegetable fibers like sisal, hemp, flax, and cotton. Any of these can be used in powder manufacture—even wood—but in this country at the present time powder is made using cotton.

A mixture of SULFURIC and NITRIC ACIDS acting on the cotton performs the main chemical transformation of innocuous cotton into a high explosive.

A mixture of ETHER and ETHYL ALCOHOL (grain alcohol) is used as a solvent for the acid-treated cotton.

DIPHENYLAMINE serves as a stabilizer for the powder. This it does by reacting with the acid-forming gases produced as the powder deteriorates. These, if not absorbed, encourage further deterioration; thus the presence of diphenylamine slows down deterioration. It does NOT completely stop deterioration.

The first step in processing the cotton is to purify it. This is a fairly elaborate operation, which begins with cleaning seeds and other visible impurities out of the cotton, and continues with boiling it in sodium hydroxide (lye) solution, washing, chemical bleaching, and more washing. Since cotton purified this way is used in a number of industries besides powder manufacturing, purification is often accomplished by specially equipped plants before the cotton is even delivered to the powder plant.

When purified, the cotton is ready for the first step in actual powder manufacture—treating it with a mixture of sulphuric and nitric acids. This treatment, termed NITRATION, yields an explosive compound called PYROCELLULOSE (PYRO for short) or NITROCELLULOSE. (It may have still another name—guncotton.) Then the pyro is beaten to a pulp by machines, so as to break up the cotton fibers, further purified, and dried in big hydraulic presses which pump alcohol into it and mold it into large blocks. The blocks next go to "block breaker" machines which break them up so that the pieces can be inserted into mixing machines which knead them and add to them an ether solution containing diphenylamine.

Then the powder is again pressed into blocks, which are squeezed through a "macaroni" press that converts the blocks into long solid macaroni-like strands. (As you can guess, the point of all this breaking, mixing, purifying, molding, and so on is to eliminate entirely the original fibrous structure of the cellulose in the cotton, and to make the pyro a completely amorphous or structureless mass.) Once more, the strands are pressed into a block, and at length the powder is forced, for the last time, through a die which squeezes it out or extrudes it as a perforated cord of circular cross section. The cord goes through a grain cutter which cuts it into grains of uniform length.

By now the powder looks pretty much as you see it in figure 5-1, but it is still soft and "green," because it contains too much of the ether and alcohol solvents. So it goes next to "dry houses," where excess solvents are dried out—a 2 to 3-month process. After drying, the powder is blended with other batches of similar powder to make up an index. Samples from the index are made into charges and proof-

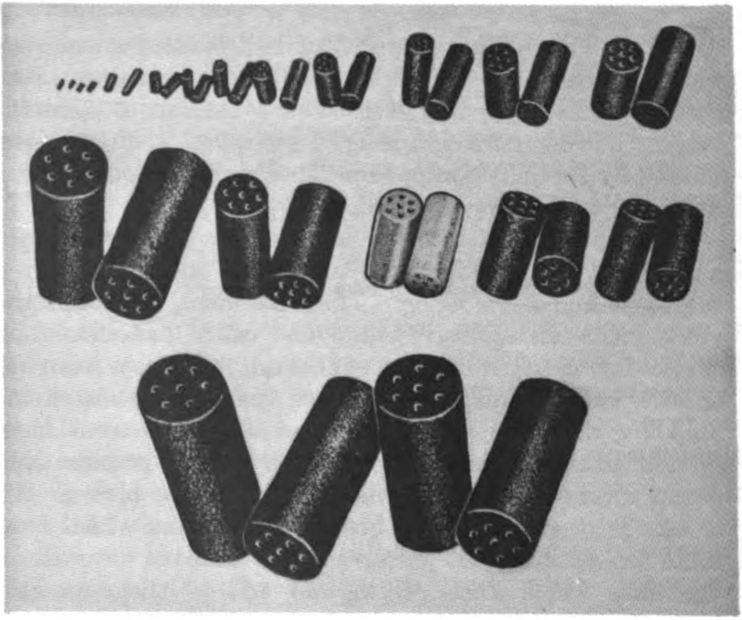


Figure 5-1.—Smokeless powder grains, cal. .30 to 16"/50 cal. The two white grains are SPCG powder.

fired to check its performance. After the index has been formally accepted by the Navy, it is assigned an index number and is ready for issue to the Fleet.

CHARACTERISTICS AND IDENTIFICATION OF SMOKELESS POWDER

Each index is assigned to one caliber (sometimes to more than one, if it is suitable) and is used to make up propellant charges, with a definite weight for each charge, as determined by projectile used and muzzle velocity desired. Index numbers are assigned serially, No. 1 having been the first. The number itself can tell you nothing about the powder except its approximate age, but the group of letters preceding the numerals identifies the powder in more detail as follows:

SPD. The letters SP stand for pyro-type smokeless powder. That the smokeless powder is stabilized by addition of diphenylamine is indicated by the letter D.

SPDN. Stabilized smokeless powder, with the addition of certain nonvolatile materials that reduce the tendency of smokeless powder to absorb and retain water. This tendency is termed HYGROSCOPICITY. Powder treated to prevent it is called NONHYGROSCOPIC, and ammunition containing such powder is often referred to as NH.

SPDX. Stabilized smokeless powder, water-dried nonhygroscopic. In water drying, the long air-drying period for eliminating excess solvents, mentioned in the previous section, is replaced by a shorter time in tanks of warm water, followed by a brief air-drying period. "X" powders are being reworked or replaced by new powders.

SPDF. Stabilized flashless powders, in which muzzle flash is reduced by addition of potassium salts or other chemicals.

SPDW. Reworked powder, made from ground stabilized smokeless powder.

SPDB. A blend of stabilized smokeless powders, to utilize small remnants of other indexes for target practice use, or to provide an index large enough for a ship's service allowance.

SPCG. This propellant, though relatively new to the U. S. Navy, is similar to the British powder "Cordite." It differs in composition and color from the other smokeless powders listed above, which contain but one explosive component—pyrocotton—and are therefore termed SINGLE-BASED. SPCG, though termed a DOUBLE-BASE powder, contains three main explosive components. These are NITROGUANIDINE (55 percent), NITROCELLULOSE or pyrocotton (19 percent), and NITROGLYCERINE (18.7 percent), which, you remember, is the active agent in dynamite. The remaining 7.3 percent is the stabilizer, called CARBAMITE or ETHYL CENTRALITE. In spite of containing three powerful explosives rather than just one, SPCG is a lot more stable than SPD powders because it contains much more stabilizer, much less of volatile solvents, and much less of the relatively unstable pyro.

SPCG is made in the same grain sizes and perforations as

SPD powders, and gives similar performance. In general, SPCG is handled like and is governed by the same regulations as other smokeless powder, except for surveillance (oven) tests, described later in this chapter.

In this chapter, the term SMOKELESS POWDER refers to diphenylamine-stabilized (SPD type) powder, unless SPCG is specifically designated. New designations are added to the list above as new types of powder are developed. SPCG is the most recent addition. In the past there have also been powder indexes designated SP (smokeless powder without stabilizer) and SPR (smokeless powder with a chemical that indicated powder stability by changes in color), but none of these are now in service.

Smokeless powder grains (diphenylamine-stabilized type) as they come out of the cutting machine are light ivory in color. After they have been dried, they are usually amber and somewhat translucent. As the powder ages, it becomes dark brown, then black and opaque. These color changes do NOT indicate any significant loss of stability. Reworked powder may be dark brown or black to begin with. Powder in good condition has a hard, smooth, horn-like finish.

SPCG is chalk-white and opaque when new, and yellows slightly with age. After prolonged deterioration has set in, SPCG darkens to brown and tends to scale off. However, SPCG deteriorates much more slowly than diphenylamine-stabilized powder.

How Smokeless Powder Deteriorates

As it ages, smokeless powder undergoes changes that eventually make it dangerous to store and use. The speed of this deterioration depends largely on the conditions under which the powder is stored. Mere age does NOT necessarily imply deterioration. The main reason for periodic inspection and testing of smokeless powder is NOT to find out whether the powder is old or not, but to determine whether it is safe to store and use.

Chemically, the aging of smokeless powder can be described as a process of slow decomposition or breaking up of the compounds of which it is made. The burning of the powder is mainly a similar process of decomposition, but at a much higher rate.

As explained earlier in this chapter, the products of this decomposition have an acid reaction which increases the rate of further decomposition. The diphenylamine stabilizer found in all present smokeless powder (except SPCG) slows down this breaking-up process by absorbing its products as they are evolved. But the stabilizer does not and cannot halt the breaking-down process. In any event, this can go on for some time before the powder becomes dangerous to store and handle. It is the function of violet-paper and surveillance-oven tests to indicate the rate and extent of deterioration.

But why does partial decomposition of its nitrocellulose make powder dangerous to store?

To answer this question, let us examine the decomposition process in more detail. The main product of decomposition of nitrocellulose is an oxide of nitrogen which, upon exposure to the oxygen in the air, is further oxidized to produce the corrosive reddish-brown nitrogen dioxide fumes that you associate with badly deteriorating powder. Powder decomposition also produces heat. When, as in badly deteriorated powder, decomposition is going on at an accelerated rate in a sealed powder tank or cartridge case, the heat of decomposition and the increased pressure of the gases produced may, in combination, cause the powder to ignite. That is why partly decomposed powder is unsafe to store.

But decomposition of nitrocellulose isn't all that can happen to smokeless powder. It can also lose its volatile components by evaporation. Though this loss does not make it dangerous to store, one serious effect is to make the powder BALLISTICALLY unsafe, by increasing its rate of burning when fired to such a point that dangerous chamber pressures are developed. This is why it is so important to be sure that smokeless powder propelling charges are always in SEALED powder tanks until just before firing, so that the volatiles will not escape.

INSPECTING AND TESTING SMOKELESS POWDER

Now that we have considered how smokeless powder goes bad and what makes it dangerous in its deteriorated state, it is easy to see why it is so important to determine just how safe the propellant in your ship's magazine is.

You already know that there are two main ways of doing this—by chemical tests and by visual examination. Let's first briefly review the visual methods.

VISUAL INSPECTION

As you know, when ammunition containing smokeless powder is issued to a ship, samples of each index accompany it. One of these samples is enclosed in a glass bottle with a strip of N/10 methyl violet paper. This sample, called the MAGAZINE SAMPLE, is used in the violet-paper test (to be reviewed later in this chapter) and in visual tests of the condition of the powder. The other sample is enclosed in an airtight container and is called the REPLACEMENT SAMPLE. It is used for making the fortnightly visual test, and for bringing up to prescribed weight charges from which samples have been drawn. When the ammunition index is transferred, these samples go along with it.

Magazine samples and replacement samples are stowed in the same magazines as the index of powder they represent. That subjects them to the same storage conditions. Racks are usually provided for stowing the bottles containing magazine samples, but the replacement samples are often stowed on top of the other powder cases.

The visual examination itself requires inspection of the powder grains while they are in the bottle. The grains in the magazine sample are examined daily; the replacement sample is examined every two weeks.

When you examine the powder for its appearance, make the examination in good light. Powder in service comes in various colors, ranging from white to amber and black. Stabilized powders may become black after only very slight decomposition, so that darkening of the grain is not a reliable test of the powder's stability. The grains may be dead black and still have 90 percent of the stabilizer present.

When a grain of powder has decomposed considerably, dioxides of nitrogen are always set free, which attack the alcohol present in the grain. Fine, hairline cracks develop on the edge of the grain. It becomes friable, or brittle at the edges, and parts may be broken off much like sugar, even though the remainder of the grain is tough and horn-like. Grains which have developed even the first states of brittleness will show a very low violet-paper test and surveillance test, and such tests should be made to confirm your diagnosis.

Signs of deterioration to look for in smokeless powder, then, are:

1. Discoloration of the grains; grains differing in color; grains with orange or yellow spots. Note that mere darkening of grains is not itself an indication of deterioration.
2. Grains showing fine surface cracks, particularly if the grains are of a dry appearance without normal glossy hard surface.
3. Easily crumbled grains. This applies particularly to the discolored spots on the grains and to the off-colored grains.
4. Soft or mushy grains. If these are present, open the sample bottle to check for fumes.
5. Reddish-brown or orange fumes. These are nitrogen dioxides, and, with Nos. 3 and 4 above, indicate very serious deterioration. The fumes have a very sharp, pungent odor. Be careful not to confuse this odor with the normal odor of ether and alcohol, or that of vinegar (acetic acid) in powder that is old but still good.

Visual inspection is not confined to the magazine sample. You will also inspect selected charges from the magazine. The same general procedure applies, but you will find the various powder smells considerably stronger because of the greater quantities of powder involved. Inspect the cartridge cases and powder tanks, too. If the powder is badly decomposed, the metal containers are likely to show green and white corrosion; in severe cases, you may even see the reddish nitrogen oxide fumes. Remember that the presence of these fumes (whether you detect them by smell or sight) are IMPORTANT DANGER SIGNS.

The characteristics described above apply to diphenylamine-stabilized powders. SPCG changes color slowly from chalk-white to slightly yellow as it ages, but this is NOT a sign of serious deterioration. SPCG is much more durable than other smokeless powders, and it can age for quite a long time before it can be considered seriously deteriorated. SPCG samples under continuous oven test for a number of years begin to show deterioration by turning brown and scaling off at the surface, but you are not at all likely to encounter it in such condition. Since it contains only a small proportion of pyro, SPCG yields relatively small amounts of nitrogen dioxide as it deteriorates, so that odor does not help in determining its state of preservation.

Disassembly of Propelling Charges

When instructions in this chapter tell you to break down propelling charges to obtain powder samples, they refer to bag charges or to semifixed cartridges with cork plugs. Instructions for closing and resealing the latter appear later in this chapter.

In general, you will NOT be expected to break down any fixed ammunition, or any semifixed ammunition with pyralin plastic closing plugs. These are all classed as CRIMPED ammunition. No replacement samples are furnished with indexes of crimped ammunition, and the customary inspections of such samples are therefore not required. Nor will you conduct surveillance tests of crimped ammunition; present regulations (published in OCL A11–50) provide that ships will forward samples to ammunition depots for breakdown and surveillance testing. More on this later in this chapter.

In a nutshell, you can (if you know how to do it right) break down bag charges and semifixed cartridges to inspect and obtain samples, then add powder from the replacement sample, and reassemble the charges. You may NOT break down case ammunition classed as CRIMPED, whether fixed or semifixed, unless (1) you are specifically authorized to do so by your gunnery officer, (2) you know how to break down, reassemble, and reseal the ammunition, and (3) you have the machinery and tools available to do the job.

VIOLET-PAPER TESTING

The purpose of the violet-paper test is to maintain a sensitive running check on the actual condition, at the moment, of the powder of a specific index in the magazine. As you know, in this test a small sample of powder from that index is kept in a sealed glass bottle with a strip of violet paper. This sample, along with the other samples being tested at the same time, represents the entire index. The idea is (1) if the sample is truly representative (that is, if the sample behaves like the rest of the powder of the index), and (2) if you stow the sample under exactly the same conditions as the remainder of the index, then any indication of the condition of the sample will show the approximate condition of the entire index.

To make the sample representative, the powder in it is selected at random. That is, any powder grain has just as much chance to be in the sample, in theory, as any other powder grain. Moreover, to be as certain as possible that no sample is unrepresentative because it may contain powder that is in significantly better condition than the rest of the sample, there is usually more than one sample under test at one time.

The violet-paper test depends upon the fact that the oxides of nitrogen produced by powder decomposition will react with a certain dye, bleaching it out. When magazine samples are received aboard ship, each contains a strip of violet-dyed paper. A supply of violet paper is also carried aboard ship so that new tests may be started. The dye used to color this paper is called methyl violet. These strips are of a standard size and the dye is of a specified strength designated as one-tenth normal or N/10. When a strip of violet paper is exposed in a sealed bottle to a sample of powder, the dye is attacked by the oxides given off by the powder. Only one strip is exposed to a sample at one time.

The time required for a change of color from violet to white is an indication of the relative rate of the decomposition of the powder. The color of the paper changes gradually, first to a paler purple, then to a light blue, and finally the color is completely lost, leaving the paper pure white. The total loss of color of violet paper should be checked by an examination in good light and by comparison with a clean sheet of white paper.

Never open a bottle at any time while the violet-paper test is going on. The same paper can remain indefinitely in a bottle so long as it does not turn white. Serviceable powder should not turn paper white in less than two months. In some cases, the same test has run continuously for years before the paper changed color.

When any noticeable change of color appears in the paper within two months, start another sample bottle immediately. Such a change in color within two months after a test has been started indicates that the powder is nearing a critical stage of decomposition. Besides starting a new violet-paper test bottle, you must break down at least three charges chosen at random from the index to inspect the grains. And you must have a sample tested in the surveillance oven.

It may be difficult to detect the first changes in violet-paper color. Often the paper begins to bleach at the edges or in isolated spots before fading uniformly. Look for these faded or bleached areas. Another way to detect this first fading is to compare the paper in the magazine sample with brand-new paper in its original storage bottle. If there is a noticeable difference in color between new paper and the paper in the magazine sample bottle within two months, that's your sign to start new tests, as mentioned above.

Best of all, if published color standards are available from the Bureau of Ordnance or other competent authority, use them.

It is important to bear in mind that unless you have special instructions from competent authority, the violet-paper test of magazine samples is supposed to continue until the paper is completely bleached out to PURE WHITE. This is important. The first fading, referred to above, is a signal to start NEW tests, not to end the original test.

At this writing, SPCG on shipboard is tested in magazine samples with N/10 violet paper just as other smokeless powders are. However, experience has shown that violet paper tends to fade prematurely with SPCG, giving an exaggerated impression of instability. New indicator papers and techniques for SPCG are therefore now under development. For the present, regulations require that SPCG continue to be tested by N/10 violet paper, since the error is on the safe side.

Starting a New Magazine Sample

In starting a new magazine sample bottle, you select a charge at random from the magazine, break it down, and draw a sample. If the index is stowed in more than one magazine, try to get charges from several of them—especially from magazines having the most unfavorable storage conditions with respect to heat, dampness, and so on. Do similarly in selecting specific charges—for example, get your powder from damaged or leaky tanks, if there are any, and from tanks located near warm bulkheads rather than from others. Thus, any error in the selection will be on the side of safety.

When you have selected the charges from which the samples are to be drawn, you are ready to draw the samples. Each sample should come from one propelling charge only, and that charge should be tagged. Make sure your hands are clean and dry; best of all, you should wear clean cotton gloves when handling powder. Remove the powder for the sample from various parts of the case (of case ammunition) or various sections of the charge (of bag ammunition). Weigh and record carefully the amounts taken from each case or section. Next, spread out the powder from each charge on clean white cloth, mix it thoroughly, and examine the grains closely for signs of deterioration. If all the grains appear normal, select at random sufficient grains for the test sample. Return the grains not selected to their respective charges. Weigh each charge or section to make sure it is up to its exact original weight. Replenish as necessary from the replacement sample.

Warning: It is a good idea, from the point of view of safety, to expose powder from only ONE charge at a time when making up samples for any purpose.

If examination reveals deteriorated powder grains, call it to the attention of your gunnery officer AT ONCE. Determine the number of visibly deteriorated grains per pound, and select a representative sample (not less than a quart jar full) to be transferred to a naval ammunition depot or to the Naval Powder Factory, Indian Head, Md. The sample should be tagged or labeled with full identification of the ammunition (including caliber and powder index number), number of grains found deteriorated per pound, and all other pertinent information.

If your ship is equipped with a surveillance oven, you must also select from the deteriorated propelling charges two hand-picked samples—one of visibly deteriorated or questionable grains, the other of grains that look satisfactory—and subject them both to the surveillance oven test, as described in the next section. This should be done IN ADDITION to the shipment of a sample to the ammunition depot, as stated in the paragraph above.

The next step in starting the magazine sample (violet-paper test) is to load the bottles. Charges LARGER than 8″ require 12-ounce samples, which are put into 16-ounce glass stoppered bottles. Charges of 8-inch caliber and less require 6- to 8-ounce samples in 8-ounce bottles.

Into each bottle put ONE strip of DRY violet paper, marked in lead pencil with the date the test is begun. Close the bottle tightly (the glass stopper must fit snugly), tie the stopper down, place the bottle in the magazine, and keep it closed on future inspections. Magazines are usually provided with racks for stowing the bottles, but if none is available, place the bottle in the warmest part of the magazine. Because the dye may be bleached by too much light, no test sample bottle should be exposed to light any more than is absolutely necessary.

Do NOT use for violet-paper testing the non-sol bottles intended for surveillance oven testing.

Ships not equipped with a surveillance oven must have three samples of each of the different indexes of powder aboard continuously subjected to the violet-paper test. At ordinary temperatures, the paper will not become white in two months.

Care of Violet Paper

Two kinds of methyl violet paper are made for conducting tests of smokeless powder. One, known as NORMAL violet paper, has a deep tint and is used only in the laboratory for making the "German test" at 135° C. It is NOT to be used for shipboard magazine samples. The other is the ONE-TENTH NORMAL (N/10) violet paper, which has a paler tint, issued to ships and ammunition depots for testing smokeless powder at normal temperatures.

When you receive violet paper aboard ship, see if the shipping bottles are satisfactorily tight. If they are not, transfer the paper to tight glass-stoppered bottles. Violet paper can be affected by light, so store it in a dark place. The paper is not affected by ordinary handling, but it should be kept clean and dry. It is used dry.

When the paper is deteriorating, it begins to whiten around the edges. Do not use deteriorated paper for making tests. Get a fresh supply. Ordinarily, you should draw no more than a year's supply of violet paper, so that you can be sure your paper is fresh.

SURVEILLANCE TESTING

While the violet-paper test shows the PRESENT condition of the powder index being tested, and can indicate relatively sudden decrease in powder stability, it is not exact enough for predicting just how long the powder will remain serviceable under usual shipboard conditions of stowage. Since smokeless powder does not usually deteriorate rapidly and without warning, even under less than perfect storage conditions, the violet-paper test is adequate for destroyers and smaller vessels whose ammunition stocks are small enough, compared to their ammunition consumption, to make unnecessary really long-range predictions as to ammunition condition. But on cruisers and larger combat vessels, at ammunition depots ashore, and aboard ammunition supply ships, longer-range forecasts of ammunition condition are needed. This is what the surveillance oven test is intended to furnish.

The principle of the surveillance oven test is to subject a sample of smokeless powder to a controlled high temperature. Its deterioration rate at this temperature (65.5° on the Centigrade scale, or approximately 150° Fahrenheit) is, of course, much higher than at usual shipboard magazine temperature. The powder under test is kept at the prescribed temperature continuously, night and day, until it gives off the telltale red fumes that indicate the last stages of deterioration. The time required for the sample under test to break down is, of course, much less than that required for the remainder of the index to break down in the magazine. But the important point is that from the time required in the surveillance test it is possible to estimate how long the powder stored in the magazine will remain safe. Long experience and much testing has developed with considerable precision the relationship between the actual life of the sample in the oven and the expected life of the powder under normal storage conditions.

Surveillance Ovens

Now that you know the principle of the surveillance test, let us examine the ovens used for this work.

There are two types of ovens used for surveillance work at present—the Mk 5 Mod 0 and the Mk 5 Mod 1. As figure 5–2 shows, both of them are insulated metal boxes. They are equipped with thermostatically controlled electric heating elements, with racks, covers, hatches, and other accessories that adapt them to the specific task of testing smokeless powder.

Let us take up first the Mk 5 Mod 0. This consists of two metal boxes, one within the other, separated by 2¼ inches of glass-wool insulation. The outer box is made of monel metal and one end is removable to give access to a compartment, illustrated in figure 5–3, containing the electrical control equipment and connection terminals.

The inner box, or heated chamber, is made of sheet copper. It has a perforated bottom, below which are located four heaters. The heaters consist of nickel chromium ribbon wound on refractory forms. The bus bars and all electrical connections are welded to eliminate the possibility of loose connections.

The heaters are accessible by removing the bottom insulation and lower perforated plate. Below the heaters is another perforated metal sheet and below this second perforated sheet is a removable slab of insulation with a 2-inch hole in its center.

The oven cover's construction is similar to that of the oven itself—copper and monel metal sheathing, with glass-wool insulation. It has an asbestos gasket and a handle. In its center is a holder for a mercury-in-glass thermometer, which is installed, when the oven is in use, so that its bulb projects below the cover's inside surface, and the 60° mark is flush with the top of the adjusting nut which holds the thermometer in place. There are two 2-inch vent holes in the cover, with a shutter which closes down to a minimum opening of one-fourth inch.

The Mk 5 Mod 0 oven is of the gravity convection type. Air enters through the perforated bottom, is heated by the heating elements, passes through the upper perforated plate

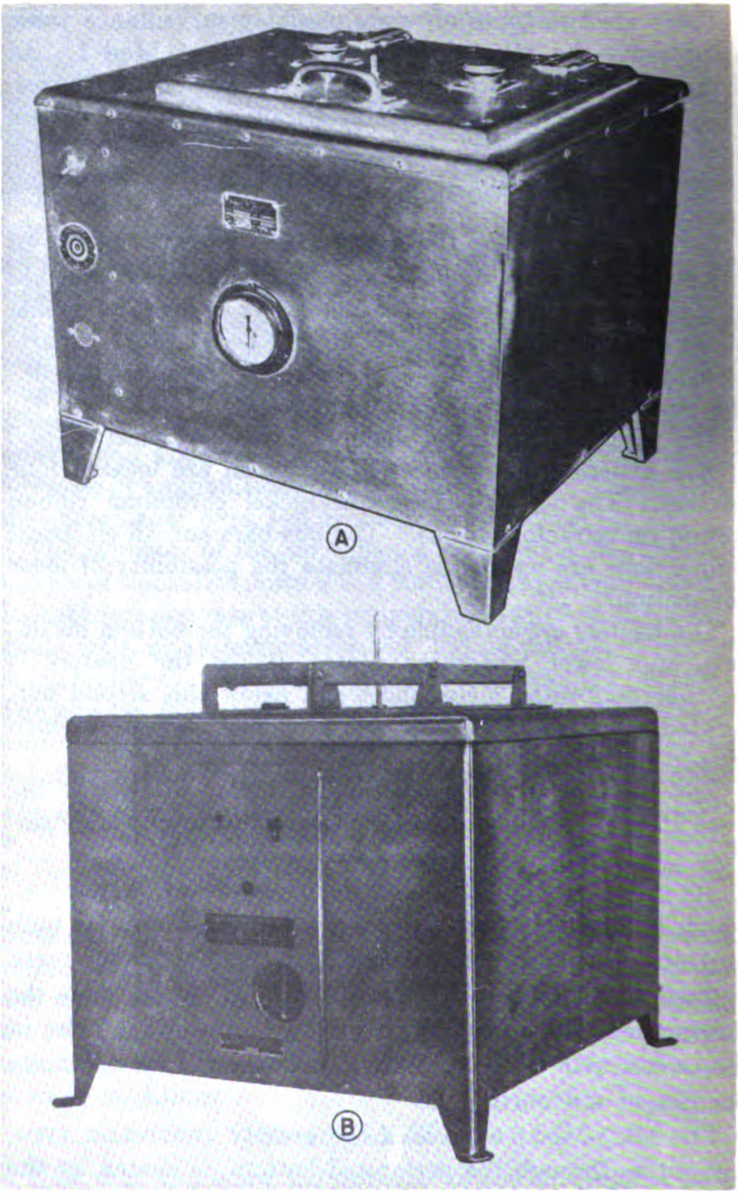


Figure 5-2.—Powder surveillance ovens. A. Mk 5 Mod 0. B. Mk 5 Mod 1.

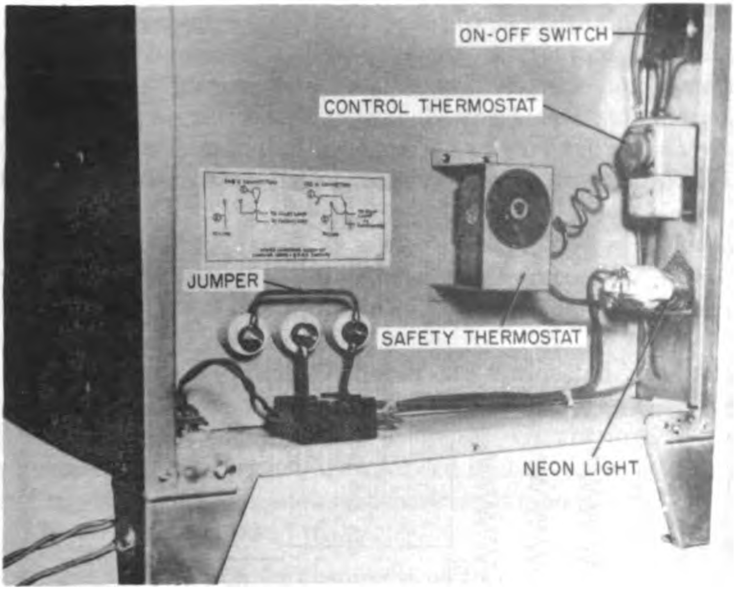


Figure 5–3.—Surveillance oven Mk 5 Mod 0, with end panel removed to show electrical control equipment. (Oven is shown wired for 120V operation.)

and around the sample bottles, and out the cover vents. The wire rack in the oven can hold 23 bottles.

The oven is designed to operate on 120 or 240 volts, either AC or DC. The four heaters and controls are connected as shown in figure 5–4.

The line connection outlet is located on the bottom of the oven near one corner of the end compartment. The oven should not be connected until the voltage of the power source is known and the connections to the heater terminals are correct. One side of the incoming line goes to the center heater terminal for 120-volt operation, and to the right-hand terminal for 240-volt operation. For 120-volt operation, a jumper is required between the outside terminals; for 240-volt operation this jumper is removed. The oven has a terminal on the frame for making a ground connection to a water pipe or a well-grounded conduit.

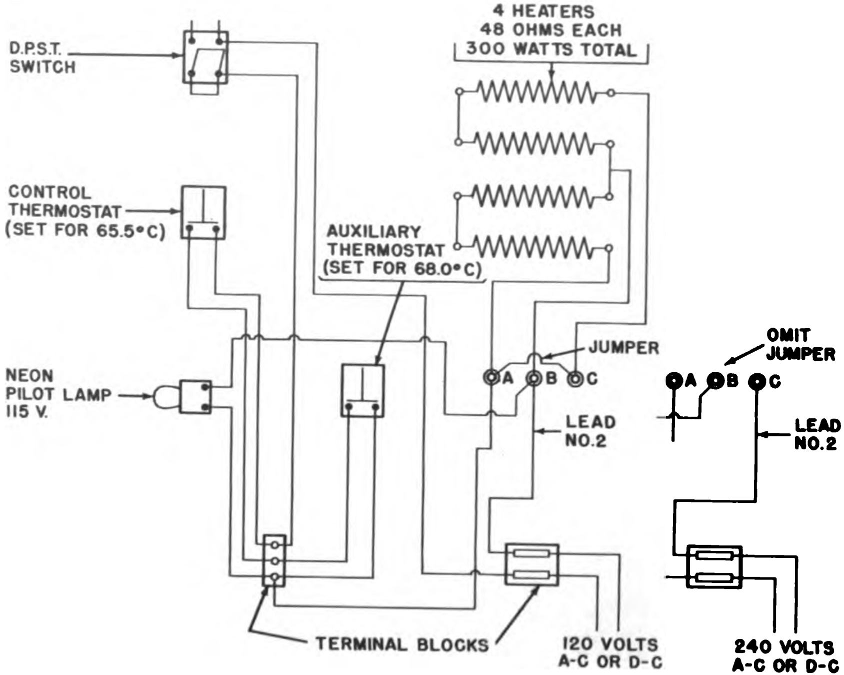


Figure 5-4.—Electrical wiring diagram for surveillance oven Mk 5 Mod 0.

The regulated oven temperature is 65.5° Centigrade, plus or minus one degree. This temperature is maintained by an adjustable thermostat. The sensitive element of this unit is a helically formed tube located between the bottle rack and the upper perforated plate. It operates a snap-action switch which is mounted in the end compartment as shown in figure 5–3 so that its adjustment shaft extends through the front panel.

The oven safety device to prevent overheating is a second thermostat with similar sensitive element and switch, but it is permanently set to shut off the power if the temperature exceeds 68° C.

These two thermostat switches are connected in series with each other and the heating elements. The safety switch and thermostat, once set to 68° C, are NOT to be adjusted. Both switches are enclosed in dust-tight housings and must never be cleaned or otherwise tampered with.

The oven also is fitted with:

1. A toggle switch for turning it on or off.
2. A neon light which glows when the heaters are energized.
3. A dial-type thermometer which shows the temperature in the heated chamber.
4. A FUME TUBE—a hollow sealed glass tube containing enough gaseous nitrogen dioxide to color its contents.

Drafts and outside heat sources have a bad effect on the oven's temperature regulation. Therefore, it must be installed where no drafts will blow directly against it. There must be no radiators, steam pipes, or similar heat sources nearby, nor windows, ventilators, or other sources of air currents. Electrical installation requirements are that the oven be grounded and that the oven's internal connections be specifically made for the supply voltage available.

To operate the oven, first turn the snap switch to ON position to energize the heaters. The neon pilot light will glow. Then allow the oven to come to equilibrium temperature. This will require about 2 hours. At the end of this time, read the mercury thermometer in the cover. It should read 65.5° Centigrade plus or minus 1°, over a period of time during which the pilot light goes on and off twice.

Only after the oven has reached equilibrium should the sample bottles be loaded into the racks. When loading the oven, if less than 23 bottles are used, they should be arranged symmetrically in the rack. Avoid, particularly, putting all the bottles in one corner. If possible, fill all vacant rack spaces with empty bottles.

The mercury thermometer is the basic temperature measuring device for this oven. When using the oven for the first time, and periodically after that, check the operating temperature with this thermometer. If the operating temperature is found to be outside the allowable limits, adjust the control thermostat, using a screwdriver. Turning clockwise increases the temperature setting; counterclockwise, decreases it. After making any adjustment, allow at least 15 minutes for the oven temperature to stabilize.

The thermostat dial is graduated, but the divisions do NOT correspond to temperature settings in terms of degrees, and are to be used only for reference in making adjustments.

The dial thermometer on the front panel should always agree with the more accurate mercury thermometer. If it does not, remove its cover and turn the adjusting screw until the reading of the pointer agrees with the mercury thermometer. The dial thermometer is for convenience in checking the oven temperature from a distance, and it must be compared with the mercury thermometer from time to time and brought into agreement.

NOTE: The thermostat setting should NOT be changed on the basis of dial thermometer readings. Use only the mercury thermometer for this purpose.

The surveillance oven Mk 5 Mod 1 closely resembles in outward appearance the Mk 5 Mod 0. The inside is somewhat different, however. The heated chamber is cylindrical, and the oven walls have no perforations.

The electrical and control equipment is in a compartment in the front wall of the oven, as illustrated in figure 5–5.

Located in this compartment are the line switch, control and safety thermostats, neon pilot light, dial thermometer, and terminal board with jumper links, for making connections for operation on 120 or 240 volts.

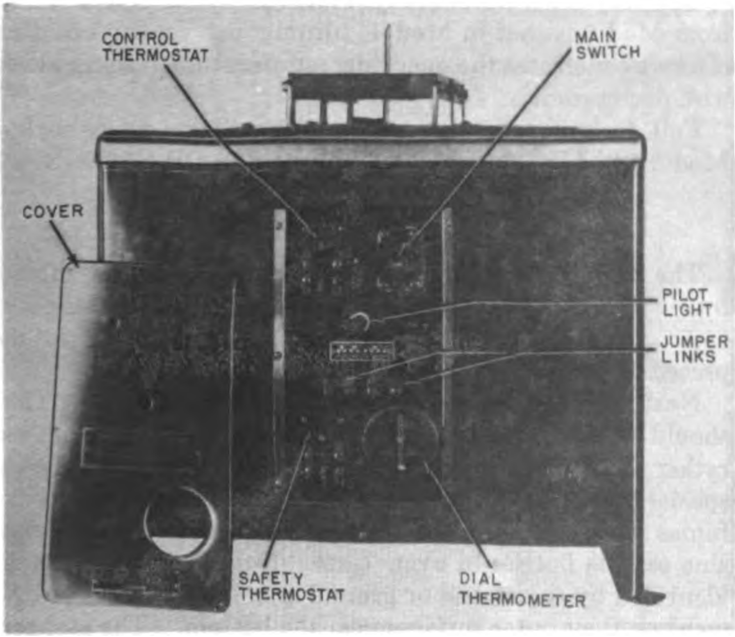


Figure 5–5.—Surveillance oven Mk 5 Mod 1: Control equipment.

The heater elements, which consist of two circular loops wrapped closely around the cylindrical inner chamber, are of the "Calrod" type, with the resistance wire completely enclosed in a metal tube. The oven depends more on cross radiation and conduction than on convection of air currents to heat its contents. The cover is like that for the Mk 5 Mod 0, except that it contains only one small breather vent.

The installation and operation of the Mk 5 Mod 1 oven are different from the Mk 5 Mod 0 only in minor details. The wiring diagram for the Mod 1 is shown in figure 5–6. The Mk 5 Mod 1 oven is less sensitive to drafts and external heat sources, since it does not depend on air circulation for heat distribution. You can expect it to perform satisfactorily in any location where external disturbances cause no difference in temperature that can be discerned by touch at any two points on the box.

The only other noteworthy respect in which Mod 1 differs from Mod 0 is that in Mod 1, turning the control counterclockwise increases the operating temperature; turning clockwise decreases it.

Full technical details on the surveillance ovens Mk 5 Mod 0 and Mk 5 Mod 1 are published in OD 4598.

Surveillance Test Procedure

The first step in starting the smokeless powder surveillance test is to heat up the oven until its temperature stabilizes at 65.5° Centigrade. This procedure was described in the preceding section.

Next, prepare the bottles to be used in the test. They should be washed and thoroughly dried, preferably in an oven rather than with a cloth. Make sure that the bottles are the special NON-SOL type, since ordinary glass is discolored by the fumes released during the test. NEVER use ordinary magazine sample bottles in oven tests. Non-sol bottles can be identified by the etched or ground area (about 2 inches by 1 inch) on their outer surfaces near the bottom. The stoppers should fit snugly. If they do not, they must be carefully hand ground until they do fit. Tie the proper stopper loosely to its bottle with a piece of twine so it won't be mislaid, but DON'T tie the stopper down when you are running a test. This is necessary because the stoppers must be free to lift slightly as internal pressure from fumes in the bottle forces them up.

The powder to be used is obtained by breaking down a service charge. Take samples from several different magazines, but especially from magazines having the most unfavorable storage conditions of temperature and dampness. Take five whole grains of powder from major caliber charges (8″/55 caliber size and larger), and about 45 grams of whole

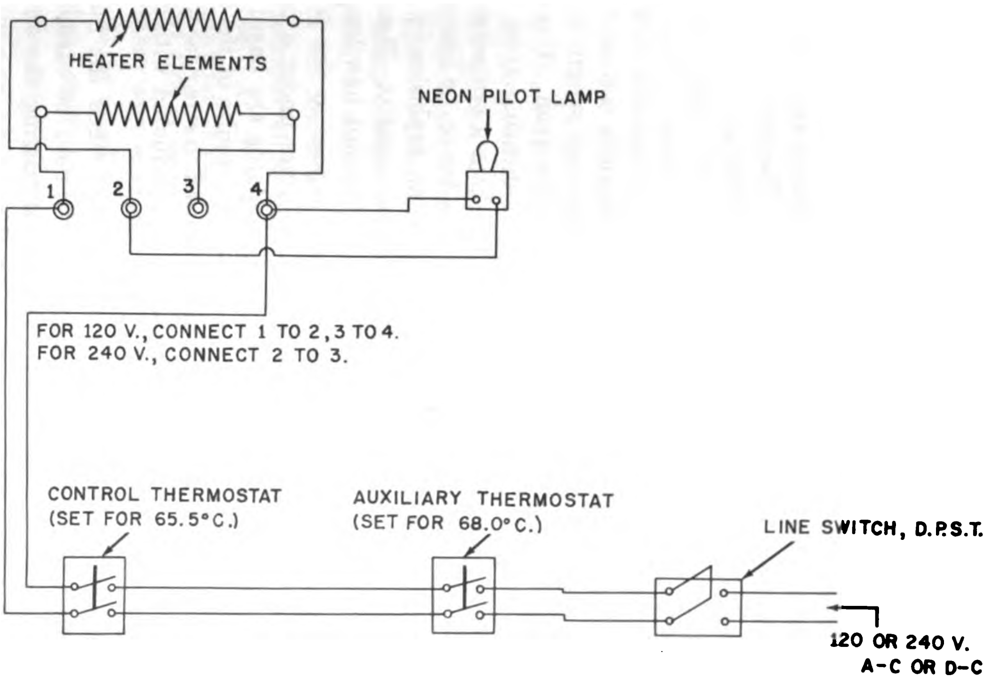


Figure 5-6.—Surveillance oven Mk 5 Mod 1: Wiring diagram.

grains of powder from charges of smaller caliber. (DON'T break up any grains to make the weight exactly 45 grams.)

After you count out or weigh the exact quantity for the sample, bring the charge back to full weight with a like amount from the replacement sample.

Put the selected sample in the bottle and fit the stopper snugly. Mark on the etched space on the bottle the necessary data pertaining to the index of the powder and the date. Then place the bottle in the oven.

If the oven is not full of bottles, the vacant places should be filled with empty stoppered bottles. The oven holds 23 bottles. If fewer are used, they should be arranged symmetrically in the rack. Don't put them all in one corner; space them out.

The test requires that the temperature within the oven be kept within one degree of 65.5° C. Although the controls can be expected to maintain the temperature within these limits, a frequent check must be made on the oven. Too low a temperature will spoil the test by indicating that the powder is safer than it actually is. Too high a temperature will spoil the test by indicating the powder to be less safe than it actually is; besides, it may cause an explosion of the powder under test by decomposing it too rapidly. Bear in mind that the purpose of the test is to find out how long it will take the sample of powder to decompose to the point where it will produce nitrogen dioxide fumes under a CONSTANT temperature of 65.5° C. As standards are based on this temperature, it is easy to see that the results of the test will mean little if the temperature is allowed to stray far from 65.5° C. Therefore, the test should be conducted with care and the instructions followed to the letter.

Because it is impossible to predict just when the fumes will appear in the bottles, each bottle should be examined DAILY. The examination consists of comparing the bottle with the FUME TUBE (a sealed glass tube containing nitrogen dioxide) against a white background to detect the characteristic reddish nitrogen dioxide fumes. The bottle should

NOT be opened during the test, and its time out of the oven should be as short as possible.

When red fumes appear in the bottle, the test is completed. Keep a record of the number of days elapsed from the beginning of the test to the appearance of the fumes. The number of days required for the fumes to appear is the measure of stability of the powder.

Even when there is doubt as to the presence of the fumes at a daily examination, the mere suspicion of their presence should be carefully noted. A close examination should then be made on the following day, when the additional 24 hours should have considerably increased the depth of color. Here is where the fume tube comes in handy. Without something to compare with, a fairly substantial concentration of nitrogen dioxide can build up before you begin to notice its reddish-brown color. Or, on the other hand, you may think you detect a trace of it in the non-sol bottle before any significant amount has actually collected. In the former case, you will overestimate the powder's durability; in the latter, you will put it down as much farther gone in decomposition than it actually is. But the fume tube contains just the concentration of nitrogen dioxide that you should look for. Make the comparison in a good light, holding up the sample bottle and the fume tube against a white background, as shown in figure 5–7.

In the course of the test, smokeless powder often produces a greenish-yellow deposit that coats the inside surface of the bottle. An inexperienced observer can easily mistake this deposit for the red fumes of nitrogen dioxide. One way to avoid this error is by use of the fume tube for comparison. Another way is to invert the bottle. The lower part of the bottle is usually unstained. The Naval Powder Factory recommends that if the coating is bad enough to impede proper detection of fumes, the sample under test should be transferred to a freshly cleaned and preheated bottle and the test continued.

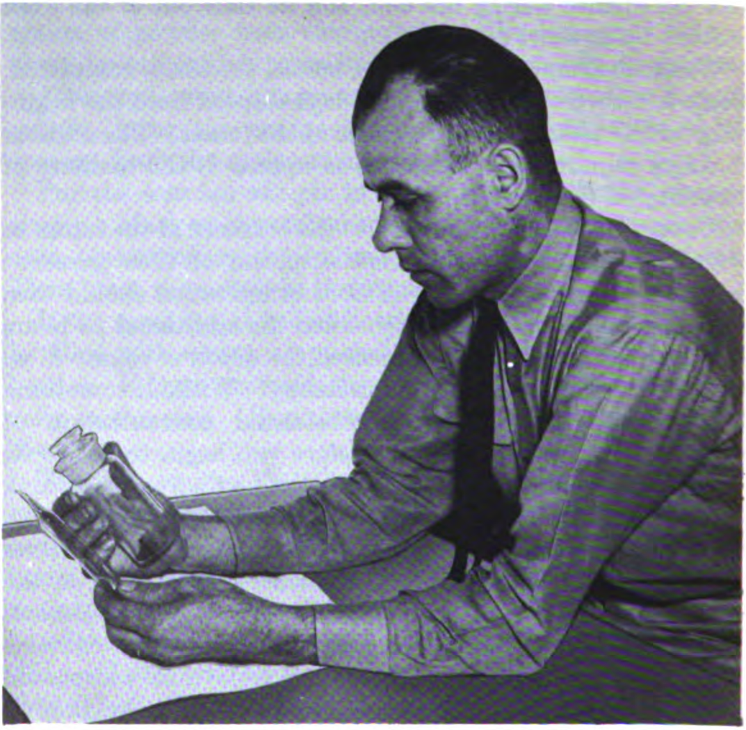


Figure 5–7.—Comparing surveillance sample bottle with fume tube.

Ordinarily, if red fumes do not appear in 60 days, the test is discontinued. You may, however, receive specific instructions to carry the test beyond this time.

When red fumes appear in a sample bottle, the bottle must be removed from the oven promptly. Since the presence of the nitrogen dioxide fumes greatly increases the rate of decomposition of the powder, the sample may explode if the test is carried too far.

After a test is completed (when red fumes have appeared, or the test has run 60 days), the powder sample is thrown overboard and the bottle washed and dried.

That, in general, is the procedure for surveillance testing of SPD-type smokeless powder.

Surveillance Testing of SPCG

The principle of the surveillance test for SPCG is a little different from that for SPD powders. Evolution of fumes from SPCG is determined by using N/10 paper, rather than by comparison with a fume tube. Here is the procedure, as prescribed by current instructions:

1. Set up a sample bottle and put it in the oven in the usual way.
2. After 24 hours, remove the bottle from the oven, remove the stopper, put in a fresh strip of N/10 paper, and immediately replace the stopper. The bottle must not be open for more than 2 seconds. Then put the bottle back into the oven. (Use heavy gloves and a face mask while handling the bottle during this test.)
3. After 1 hour, take the bottle out of the oven and examine the strip. If the strip has NOT lost its color, close the bottle and return it to the oven immediately.
4. Repeat steps 2 and 3 for 20 additional days. Use a new strip each day.
5. If the strip fades completely during any of the 21 observation periods, the powder the sample represents must be disposed of. Turn the ammunition in to an ammunition depot, if one is available, or dispose of it otherwise in accordance with present regulations.

Resealing Cartridge Cases

Cartridge cases that have been partly disassembled to permit access to their contents must be reassembled and resealed airtight (with their full charges made up from replacement samples, as required).

To seal fixed ammunition, cover the joint between the cartridge case end and the projectile rotating band with a coat of clear shellac.

Before you seal semifixed ammunition, first inspect the old cork plug. Since the old plug is usually unserviceable, you will probably have to get a new one from spare stocks. Shellac the plug around its periphery, below the shoulder, and shellac the inside of the case mouth to a depth of about one inch. Then reset the plug in the case mouth while the shellac is still wet. Remove excess shellac.

Care in Surveillance and Violet-Paper Testing

Because the condition of the smokeless powder in your ship's magazines is a vital element in its fighting potential, and in the safety of the ship and its crew, you cannot afford to take lightly the routines of powder testing. You must follow the details of instructions for testing with painstaking care. You have already read of the serious errors in judging powder stability that small variations in the standard oven testing temperature can cause. So you will have to take this powder testing routine seriously. Here are some pointers on how to do the job right:

1. Avoid subjecting powder under test to temperature variations, whether in the oven or out. Check oven temperatures regularly with the mercury thermometer. Do not keep bottles out of the oven during inspection any longer than absolutely necessary. When transferring powder from one bottle to another, preheat the new bottle. And make sure that oven thermostatic controls are always in proper adjustment.
2. Never skip a scheduled inspection.
3. Always inspect violet paper and sample bottles in a good light, preferably natural light (but not direct sunlight).
4. Keep logs and reports scrupulously accurate and up to date. Make sure to identify ammunition lots and indexes with their FULL numbers.
5. Dispose of the contents of non-sol bottles PROMPTLY after the conclusion of surveillance tests.

Surveillance Test Danger Limits

OP 4 and the *BuOrd Manual* prescribe that when a smokeless powder yields fumes within less than a certain specified time when under test, a special report must be dispatched WITHOUT DELAY and three samples of the powder must be forwarded to the nearest naval ammunition depot. The time limits specified at the present time for the following powders are:

Caliber	*Time limit (days)*
16″	23
12″	23
8″/55 bag	19
8″/55 case	19
6″	17
5″	16
3″	15
40 mm	15
20 mm	15

BASIC SCHEDULE OF SMOKELESS POWDER EXAMINATIONS AND TESTS

Up to this point, this chapter has reviewed the manufacture of smokeless powder, how to detect deterioration by inspection, and the techniques of violet-paper testing; the sections immediately preceding have described the techniques and procedures of surveillance oven testing in some detail. Now we can present in summary form the basic scheduling of all these smokeless powder tests and inspections.

Daily. Visual inspection of each magazine sample in good light. Check the powder for its normal appearance. Check the violet paper for change in color. Check magazine temperatures on the maximum-minimum thermometer, note and record them, and adjust the cooling and ventilating systems as required so that proper storage conditions are maintained.

Fortnightly. Visual inspection of powder grains in the replacement samples for any signs of decomposition or change of color. In making the examination, take particular care to see that the replacement samples are exposed to air as little as possible, and that the containers are restored to their former airtight condition.

MONTHLY. Visual examination of powder in one or more charges of each index for signs of decomposition or changes in appearance. At the same time, you should remove samples for a 65.5° C. surveillance test from all indexes which gave a test of less than 30 days on the last surveillance test.

BIMONTHLY. Run a 65.5° C. surveillance test on all indexes that have given a 30 to 39 days' test on previous surveillance tests.

QUARTERLY. Run a 65.5° C. surveillance test on all indexes that have given a 40 to 59 days' test on previous surveillance tests.

SEMIANNUALLY. Run a 65.5° C. surveillance test on samples from all indexes of powder aboard. This semiannual test is in ADDITION to those mentioned above. If practicable, all semiannual surveillance tests of powder afloat should be started on or about 1 January and 1 July.

SPECIAL. To be made at such times as the officer responsible for the tests considers it necessary because of abnormal or unusual conditions, such as excessive heating of the magazines. Where an index sample indicates loss of stability in the daily or fortnightly visual examination, or in the violet-paper test, it must be subjected to the surveillance test at once.

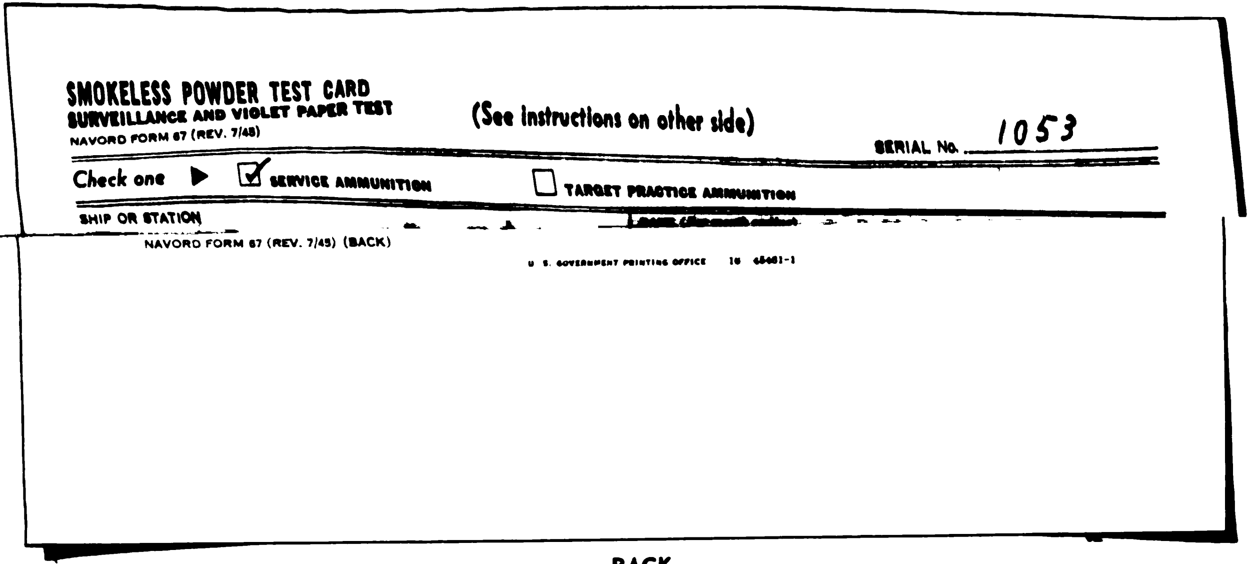
For details on the amount of exposure to heat that will warrant surveillance testing, see NavOrd Instruction 8010.2.

REPORTING SURVEILLANCE AND VIOLET-PAPER TEST RESULTS

When you have actually tested a sample of powder in the surveillance oven and by violet paper, what is the procedure for reporting the results you have come up with?

For service and target-practice ammunition, both tests are reported on the SMOKELESS POWDER TEST CARD, NavOrd Form 67, illustrated in figure 5–8.

The form is filled in and submitted to the Bureau of Ordnance upon the completion of either violet-paper tests or surveillance oven tests. On ships with surveillance ovens,



SMOKELESS POWDER TEST CARD
SURVEILLANCE AND VIOLET PAPER TEST
NAVORD FORM 67 (REV. 7/48)

(See instructions on other side)

SERIAL No. 1053

Check one ▶ ☑ SERVICE AMMUNITION ☐ TARGET PRACTICE AMMUNITION

SHIP OR STATION

[illegible]

NAVORD FORM 67 (REV. 7/45) (BACK)

U. S. GOVERNMENT PRINTING OFFICE 16 65461-1

BACK

Figure 5–8.—Smokeless powder test card (NavOrd Form 67)

c
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F

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both columns 4 and 5 must be filled in, since surveillance tests and violet-paper tests for the same powder indexes will be going on simultaneously.

Report both oven and violet-paper tests in terms of days elapsed since the test began. Since the routine oven test is terminated at the end of 60 days if the powder does NOT yield fumes, you will enter 60 plus (+) in column 4 for such tests. If the powder DOES yield fumes, enter the word FUMES in column 6; in column 4, enter the days actually elapsed with no plus sign.

Enter violet-paper test results in terms of days actually elapsed. If the violet paper still has color, add a plus sign (+) to the reported figure; when the paper is completely bleached of color, omit the plus.

There is no set maximum time for violet-paper tests; they continue until the violet paper bleaches out completely. Some violet-paper tests have continued for years. As an earlier section of this chapter pointed out, you should start a new magazine sample bottle whenever you detect ANY noticeable change in color in N/10 methyl violet paper within 2 months after starting the test. But remember that the test is not finished until the paper is COMPLETELY bleached out.

In filling out the other columns of the report form, follow the instructions on the back of the form, as they are reproduced in figure 5–8.

When Smokeless Powder Tests and Reports Are Not Required

You will of course not need to make surveillance tests if your ship has no surveillance oven. Instead, you must set up three magazine samples for each index (each sample from a different propelling charge) for simultaneous violet-paper testing. In addition, you must forward a sample bottle for each index to another vessel equipped with surveillance ovens (for instance, if you are aboard a destroyer you can ship the sample to the tender), or to an ammunition depot. Accompanying each such sample must be three copies of NavOrd

Form 67, completely filled out except for column 4, which is to be completed by the testing vessel.

Test samples to be shipped elsewhere consist of four ounces of powder in a clean, airtight glass bottle, labeled with all required information (including index number, identification of your ship, caliber, date shipped, and the like), in accordance with existing regulations. The bottle stopper must be sealed with paraffin or wax and secured with cloth covering and twine seizing. The sample must be packaged so as to minimize the risk of breakage while in transit.

ALL shipments of explosives are governed by regulations promulgated by the Interstate Commerce Commission. Parts of these regulations appear in OP 4, but your gunnery officer should have available all of those that have to do with shipment of explosive materials by rail or other commercial means.

As you remember, you need not perform surveillance tests of case ammunition with CRIMPED cartridges, or any visual inspections that require disassembly of crimped cartridges, or separation of fixed ammunition cartridge cases from their projectiles. (This includes the fortnightly and monthly visual examinations mentioned earlier.) Nor are REPLACEMENT samples for such ammunition furnished to ships. However, MAGAZINE samples (for violet-paper tests) are furnished, and violet-paper tests are therefore to be carried out in the usual way.

Instead of the surveillance testing and cartridge breakdown inspections, you will, once each year, according to OCL A11–50, when the ship is located in the vicinity of a naval ammunition depot or magazine, select at random and turn in to that activity sample rounds from each index of crimped ammunition aboard. For 20 mm and 40 mm crimped ammunition, select for each index 4 rounds from any ammunition box stored in a relatively unfavorable location, but otherwise chosen at random. For ammunition 3″ to 8″ (fixed or crimped ammunition) inclusive, select one round similarly chosen at random from each index.

Crimped cartridges are identified by OCL A11–50 as those "in which the cartridge case is crimped to the projectile in fixed ammunition or the plug in semifixed ammunition." Each round turned in must be clearly identified as to ammunition lot number, powder index, ship's name and number, and ammunition type, and must be suitably packed for transfer. The activity receiving the sample rounds will conduct surveillance tests and provide reports as to its findings to the originating ship.

You will perform NO violet-paper or oven tests on any small-arms ammunition.

DESTRUCTION AND SALVAGE OF SMOKELESS POWDER

There are occasions on which the procedures described above are not adequate for dealing with ammunition that has seriously deteriorated, or that you believe may have gone bad or been damaged too severely for service use. For example, ammunition may become wet or damaged through shipwreck or other accident, or through flooding of magazines. Under such circumstances it is not safe to restore the ammunition to service, but on the other hand it must NOT be thrown overboard, abandoned, or destroyed if it can be recovered. The proper course of action is to salvage it—recover it, pack it, and forward it to an ammunition depot. If shipment is delayed, smokeless powder that has been wet should be immersed in distilled water. Ammunition to be salvaged, and its containers, should be handled carefully and clearly labeled to indicate its condition. Be sure to forward its complete history to the Bureau of Ordnance; this information is important for guidance in reworking the ammunition.

If smokeless powder is actually in dangerous condition, then it can be destroyed—but only if it shows unmistakable signs of advanced decomposition. These are:

1. Friability of grains—that is, the grains have lost their hard finish and crumble very easily.

2. Strong odor of nitrogen dioxide fumes.
3. Very low violet-paper and surveillance tests. The conditions in 1 and 2 above must be confirmed by these tests before the powder can be destroyed.

There is one exception to these three criteria. If powder is soft or mushy, it must be thrown overboard or destroyed IMMEDIATELY.

SPCG grains in badly deteriorated condition turn brown and tend to flake off at the surface. Violet-paper tests will not be reliable for such powder. Check with the nearest ammunition depot before attempting to destroy or salvage SPCG.

NavOrd Instruction 8010.2 specifies just how much exposure to excessive temperatures renders propellants subject to condemnation.

Under ordinary circumstances, you are not likely to encounter powder that is in such sad state that it meets the above requirements for destruction. Violet-paper tests and surveillance tests are intended to prevent just this sort of thing. But you must know how to recognize powder in this condition, and know what to do if you encounter it.

Whenever any powder is thrown overboard or destroyed because it is unstable or decomposed, you must always preserve samples of each index and forward them to the Naval Powder Factory, Indian Head, Md., for examination. Notify the Bureau of Ordnance at once of the shipment and the reason for shipment. Do not pack such samples in water, but segregate them to prevent damage to other material in case of spontaneous combustion.

CONCLUSION

In this chapter we have reviewed the characteristics and manufacture of smokeless powder, and have taken up in special detail the inspections and tests of it for which you are particularly responsible. This chapter does not cover projector or rocket propellants, which are taken up elsewhere in this course.

QUIZ

Select the BEST answers in questions 1 through 4.

1. The chemical diphenylamine used in the manufacture of smokeless powder acts as
   - a. an indicator
   - b. a solvent
   - c. a bleach
   - d. a stabilizer
2. With the exception of SPCG, new smokeless powder is usually
   - a. amber with smooth hard finish
   - b. green and easily pulverized
   - c. chalk-white with fine surface cracks
   - d. shiny black with rough finish
3. As powder ages it tends to
   - a. become stronger
   - b. absorb moisture
   - c. lose volatile components
   - d. decrease in burning rate
4. The sample of smokeless powder subjected to the violet-paper test is called the
   - a. index sample
   - b. surveillance sample
   - c. magazine sample
   - d. replacement sample

In the 5 statements below check each one as either true or false.

5. While smokeless powder is not the ideal propellant, its main advantage over black powder is that it is essentially stable.
6. SPCG is the only smokeless powder containing diphenylamine.
7. Muzzle flash is reduced in flashless powders by the addition of potassium salts or other chemicals to smokeless powders.
8. All magazine samples are stowed in the coolest magazine aboard ship.
9. Treating cotton with a mixture of acids to produce an explosive compound is called nitration.

10. Select from column *B* the statement that most nearly identifies the smokeless powder referred to by each group of letters in column *A*.

Column A

(1) SPD

(2) SPCG

(3) SPDW

(4) SPDX

(5) SPDF

(6) SPDN

Column B

(a) powder with materials added that reduce the tendency of the powder to absorb and retain water

(b) powder stabilized by the addition of diphenylamine

(c) nonhygroscopic powder characterized by shorter warm-water and air-drying periods in manufacture

(d) stabilized flashless powders

Column A	*Column B*
(7) SPDB	(e) reworked powder
	(f) blend of stabilized powders
	(g) propellant differing in composition and color from other smokeless powders and with different stabilizer

Select the BEST answers in the following questions.

11. Which of the following does NOT indicate deterioration of smokeless powder?
    a. Bleaching of the powder
    b. Presence of reddish-brown or orange fumes
    c. Grains with fine surface cracks
    d. Grains easily crumbled
12. The purpose of the violet-paper test is to
    a. identify the powder as to index number
    b. maintain a continuous check on the condition of the powder
    c. indicate the minimum and maximum safe stowage temperatures
    d. provide a running check on "curing" during manufacture
13. The primary purpose of surveillance oven testing is to
    a. show the present condition of the powder in the index
    b. compare percentage of nonvolatile materials in different indexes
    c. measure burning rate of deteriorated powder
    d. predict the durability of the powder in the index
14. Samples of powder for testing should be placed in the surveillance oven ONLY when the oven
    a. is cold
    b. has been on for at least 24 hours
    c. has come to a stabilized temperature of 68° C plus or minus 1°
    d. has come to a stabilized temperature of 65.5° C plus or minus 1°
15. For the surveillance oven test, samples drawn from major caliber charges 8 inches and larger should contain how many whole grains of powder?
    a. 20 c. 10
    b. 15 d. 5
16. A surveillance oven temperature of 60.5° C will give which of the following results?
    a. Spoil the test by indicating the powder is safer than it actually is

  - b. Spoil the test by indicating the powder is more dangerous than it actually is
  - c. Cause an explosion by decomposing the powder
  - d. Make no measurable difference in the final analysis

17. The *BuOrd Manual* states that when powder tested yields fumes under a specified time, a special report must be submitted and three samples
    - a. dumped overboard
    - b. left in the oven at least 60 days
    - c. submitted to a violet-paper test
    - d. forwarded to the nearest naval ammunition depot
18. Surveillance oven tests are NOT performed aboard ship on
    - a. case ammunition with crimped cartridges
    - b. bag ammunition for 8''/55 guns
    - c. smokeless powder containing diphenylamine
    - d. 12-inch ammunition or larger
19. Reports of the results of surveillance and violet-paper tests are submitted to the
    - a. Bureau of Ordnance
    - b. nearest naval ammunition depot
    - c. factory making the ammunition
    - d. Naval Powder Factory at Indian Head, Md.
20. What is the maximum number of days a violet-paper test should be run?
    - a. 60 days
    - b. 90 days
    - c. 120 days
    - d. There is no maximum time

CHAPTER 6

HYDROSTATIC DEPTH CHARGES

INTRODUCTION

In the preceding courses of this series, you have concentrated on guns, their ammunition, and their associated gear, with not much more than a passing glance at the rest of the Navy's impressive armory of weapons. This is as it should be, because your main concern as a Gunner's Mate up to now has been guns, their ammunition, and related gear.

But, as a Chief Gunner's Mate, or Gunner's Mate First Class, you will be called upon to take over or supervise billets whose responsibilities will require a broader knowledge of ordnance than that of your immediate specialty.

You will be expected, as the *Qualifications for Advancement in Rating* provide, to know the characteristics of rocket and antisubmarine (A/S) projector ammunition, and of depth charges; and how to test, inspect, stow, and prepare such ammunition for use; and to supervise the depth charge battery. Along with this, you will need a good grasp of the operation of the launchers and projectors necessary to move this ammunition toward its target.

And, to round out the full picture of naval armament, you should know something about the principles and characteristics of other weapons—specifically, mines and aircraft bombs, for which you are likely to have little direct responsibility, but which play an important part in our Fleet's victories.

You will study all these topics in this and the three chapters following. In this chapter and the next you will study in detail the depth charges now used in the Fleet. Chapter 8 first takes up rockets and their launchers, then projectors and their ammunition, and, finally, depth charge launchers and projectors. The last chapter in this group of four is devoted to mines and aircraft bombs.

In studying these types of ordnance in this course, you will find that, in order to present the material in an orderly way, there is included a certain amount of elementary matter with which you may already be more or less well acquainted. But most of the material will most likely be new to you. It is important to study all of the ordnance equipment and ammunition discussed in this course, because you are expected to have all the basic knowledge that is presented here. And it is important for you not to overlook anything that even looks like elementary material, because, first, you must understand it in order to grasp more complex matter, and second, many of the concepts and much of the technical language associated with "non-gun" ordnance—though at first blush they resemble many that you already know—are different in many ways.

In this chapter we shall take up hydrostatic depth charges.

WHAT A DEPTH CHARGE IS

As you know, depth charges are thin-walled containers filled with a heavy charge of high explosive, designed to explode at a predetermined depth, or in close proximity to a submarine. The charge is fired either hydrostatically (by water pressure) on the exploder mechanism, or by the influence of the target (magnetic or acoustic) on the exploder mechanism. Actual contact with the submarine is not required for firing, and almost never occurs, because the exact position of the submarine is not usually known. Consequently, depth charges are designed to be effective even at some distance by creating a shock wave.

At this writing, the depth charges being issued to the active Fleet are chiefly the Mk 9 and the Mk 14, with their modifications. Both of these marks may either be dropped from release tracks or fired from depth charge projectors. Mk 6 depth charges are obsolescent; present stocks are issued for training purposes only.

The Mk 6 and Mk 9 depth charges are illustrated in figure 6–1. The Mk 14 looks like the Mk 9; the main differences are interior.

The Mk 7 depth charge, which was an enlarged edition of the Mk 6, is now obsolete. Neither will be taken up further in this course.

GENERAL DESCRIPTION OF MK 9 DEPTH CHARGES

As you can see from figure 6–1, the Mk 9 (and, by the same token, the Mk 14) differs from the Mk 6 (formerly called the "ashcan") in being streamlined for faster sinking, and finned for a better underwater trajectory. It also carries a smaller burster charge (about 190 pounds of TNT, or slightly more of HBX, as compared with Mk 6's 300 pounds of TNT). However, it is designed to be used interchangeably in the same racks and projectors as Mk 6.

Mk 9 depth charges, loaded and ready for use, weigh 340 pounds over-all. Their average terminal sinking speed is 23 feet per second. This speed can be reduced to about 15 f. p. s. by installing a flat disc called a SPOILER PLATE over the nose of the charge. These may be required when charges are dropped by small, relatively slow craft that cannot make good the minimum safe speed for dropping these fast-sinking charges.

The Mk 9 depth charge CASING is a streamlined steel shell with blunt nose (weighted with 40 pounds of lead) and tapering finned tail. It has three rings (two at the tail, one at the nose) which adapt it to launching from racks and projectors originally designed for the cylindrical Mk 6. A hole in the side is used by the loading depot for filling the

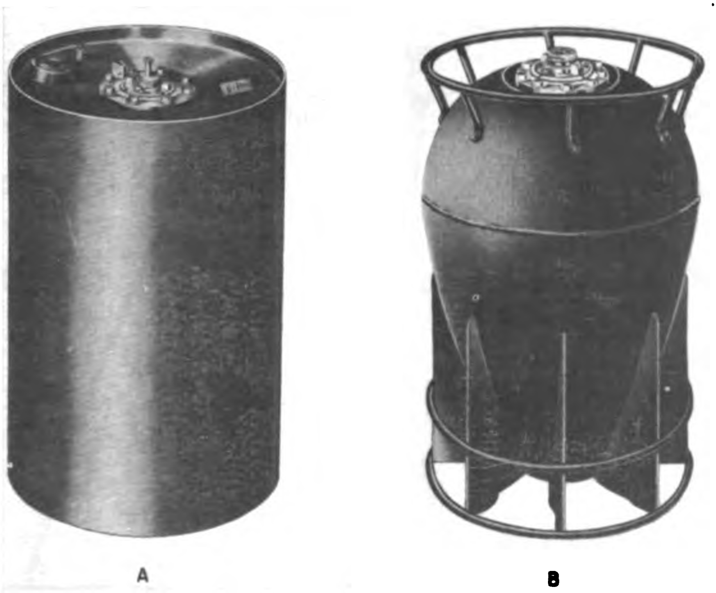


Figure 6–1.—Depth charges: A. Mk 6. B. Mk 9 Mod 2.

casing with HBX or TNT; when issued, it is sealed by a domed cover whose profile continues the streamlining of the casing.

Now let us look at the interior of the Mk 9 depth charge. (Fig. 6–2.) The components that control the functioning of the charge are housed in a central tube, a little over 4 inches in diameter, that goes all the way through the casing from nose to tail. These components are the PISTOL, the BOOSTER, and the BOOSTER EXTENDER.

General Functioning of Mk 9 Depth Charges

As you remember, depth charges can be either fired abeam from K-gun projectors on deck, or dropped from release tracks at the stern.

During shipment and stowage of a Mk 6 depth charge pistol, the inlet valve is closed by a PLAIN safety cover screwed to the valve body. When a charge is placed in a

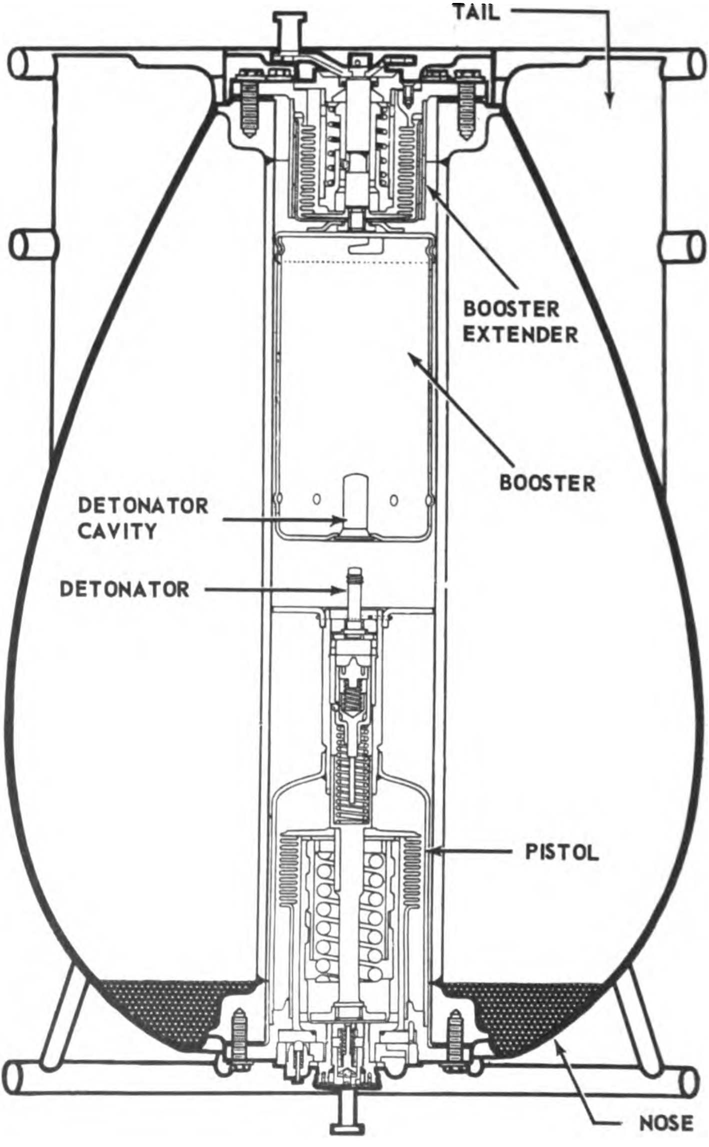


Figure 6-2.—Depth charge Mk 9 Mod 3: Sectional view.

depth charge track, this cover is replaced with one fitted with a projecting KNOB. The knob is broken off the cover by a wiping plate on the track when the charge is dropped, leaving an opening through which water can enter the pistol. If a charge is thrown from a projector, the plain cover must be removed by hand. The two are shown in figure 6–3.

The water inlet into the booster extender is kept closed by a SAFETY FORK. (Fig. 6–8.) There are two types—PLAIN and KNOBBED. The PLAIN fork, used for projector launching, is removed by hand before launching; the KNOBBED fork, for release-track launching, is wiped off by the track as the charge is released.

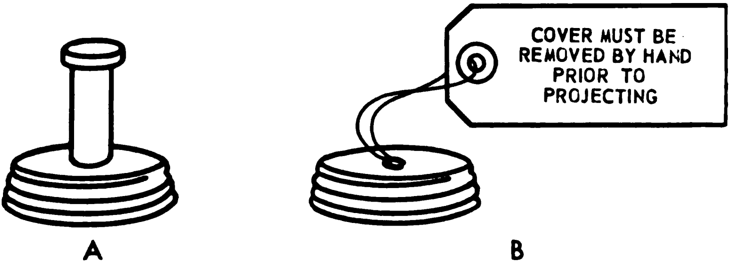


Figure 6–3.—Safety covers for Mk 6 depth charge pistols. A. Knobbed. B. Plain.

At all times before the depth charge hits the water, the detonator is separated from the booster, as shown in figure 6–2, so that explosion of the detonator is not likely to set off the booster and main charge. But when the depth charge goes into the water, the hydrostatic pressure of water flowing into the booster extender pushes the booster downward until the detonator is inside a cavity of the booster. This arms the depth charge. Explosion of the detonator can then set off the main charge through the booster. The detonator fires when hydrostatic pressure, which increases as the depth charge sinks, builds up to the point where it operates the pistol.

That's the bare outline of Mk 9 depth charge operation. Let us now examine in more detail the pistol, booster, and booster extender used in Mk 9 depth charges.

MK 9 DEPTH CHARGE ASSEMBLIES

The Mk 9 Mod 2 and Mod 3 depth charge cases (figure 6–1) are almost exactly alike. The Mod 4 has a stronger nose ring and shorter, stubbier support brackets; figure 7–1 shows it as part of the Mk 14 depth charge assembly. Mods 3 and 4 of the Mk 9 case may be used in either Mk 9 or Mk 14 depth charge assemblies.

The marks and mods of the pistol, booster, and booster extender, as associated with the three mods of Mk 9 depth charge assemblies, are shown in the accompanying table.

Depth charge	Pistol		Booster Extender	Booster	Depth Charge Case
	Designation	Depth-Setting Range (feet)			
Mk 9 Mod 2..	Mk 6 Mod 0.	30–300.........	Mk 6 Mod 0, Mod 1, or Mod 2.	Mk 6 Mod 2 or Mod 4.	Mk 9 Mod 2, Mod 3, or Mod 4.
Mk 9 Mod 3..	Mk 6 Mod 1.	30–600.........			
Mk 9 Mod 4..	Mk 6 Mod 2.	30–1,000......	Mk 6 Mod 2.		

Depth charge Mk 9 Mod 2, with pistol Mk 6 Mod 0, is obsolete. Depth charge Mk 9 Mod 3, with pistol Mk 6 Mod 1, though usable down to 600 feet, is on the way out. Both are being supplanted by depth charge Mk 9 Mod 4 (with pistol Mk 6 Mod 2, good to 1,000 feet) for active service, although you may encounter Mods 2 and 3 issued for training purposes.

Depth Charge Pistol Mk 6 Mod 2

Figure 6–4 shows the Mk 6 Mod 2 depth charge pistol in exterior view (part *A*), and in cross section (part *B*). (The pistols are shown in figure 6–4 as they would appear in a Mk 9 depth charge with nose down—its normal attitude as it sinks.)

The pistol is secured to the depth charge casing by eight cap screws through holes in its FLANGE. The flange is screwed to the MECHANISM CASING (fig. 6–4, *A*) which houses the depth-setting mechanism and bellows. At the other end of the mechanism casing is the GUIDE TUBE, which contains the base of the detonator. The CENTERING FLANGE serves to align the pistol properly in the depth charge's central tube. At the nose end of the pistol you see the DEEP-FIRING MECHANISM (which functions as an inlet valve). There are two sets of scales and pointers on the nose end of the pistol for regulating its functioning—an inner scale on the deep-firing mechanism and, concentrically arranged around it, an outer scale engraved on the flange.

Now shift your attention to the interior of the pistol, as shown in figure 6–4, *B*. Linked to the pointer for the outer scale is the DEPTH-SETTING SLEEVE. (The deep-firing mechanism is screwed into the end of this assembly.) The sleeve's internal threads mesh with those of the ADJUSTING BUSHING; the bushing, in turn, is keyed to the PISTON STEM so that the bushing can move along the axis of the piston but cannot rotate.

Rotation of the index pointer turns the depth-setting sleeve, and the engaging threads of the adjusting bushing force the bushing to move along the axis of the depth-setting sleeve. Rotating the pointer clockwise thus causes the bushing to move downward (as seen in fig. 6–4, *B*) to increase the setting to 300 feet; counterclockwise rotation moves the bushing upward to reduce the depth setting. As you will see presently, the position of the adjusting bushing regulates the action of the DEPTH-SETTING SPRING on the HYDROSTATIC PISTON.

Getting back to the piston stem, you can see that the lower end terminates in the SPRING-ENGAGING COLLAR; the tubular upper end partly houses the FIRING SPRING. The hydrostatic piston itself is held in the position shown in figure 6–4, *B* by the firing spring and the BELLOWS, which joins the disc-shaped piston in a watertight seal around the piston's edge. The lower edge of the bellows is in turn sealed to the tubular BELLOWS EXTENSION screwed to the flange.

The upper end of the firing spring fits around a shoulder

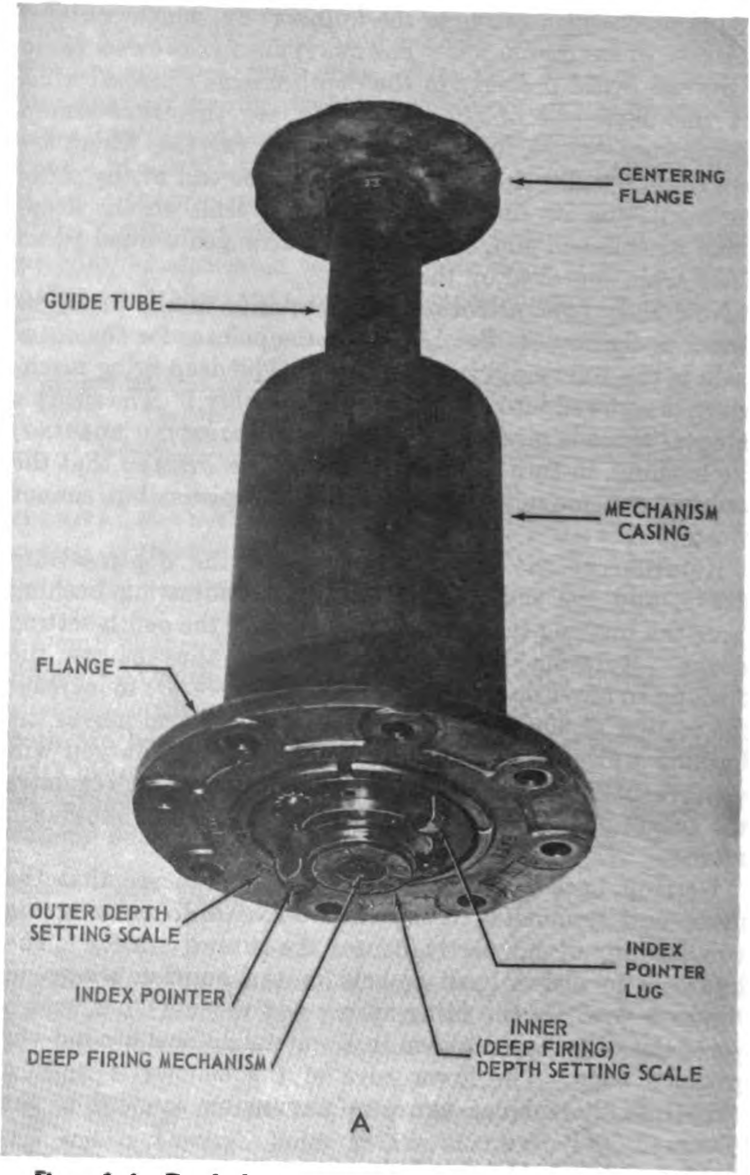


Figure 6–4.—Depth charge pistol Mk 6 Mod 2. A. Exterior view.

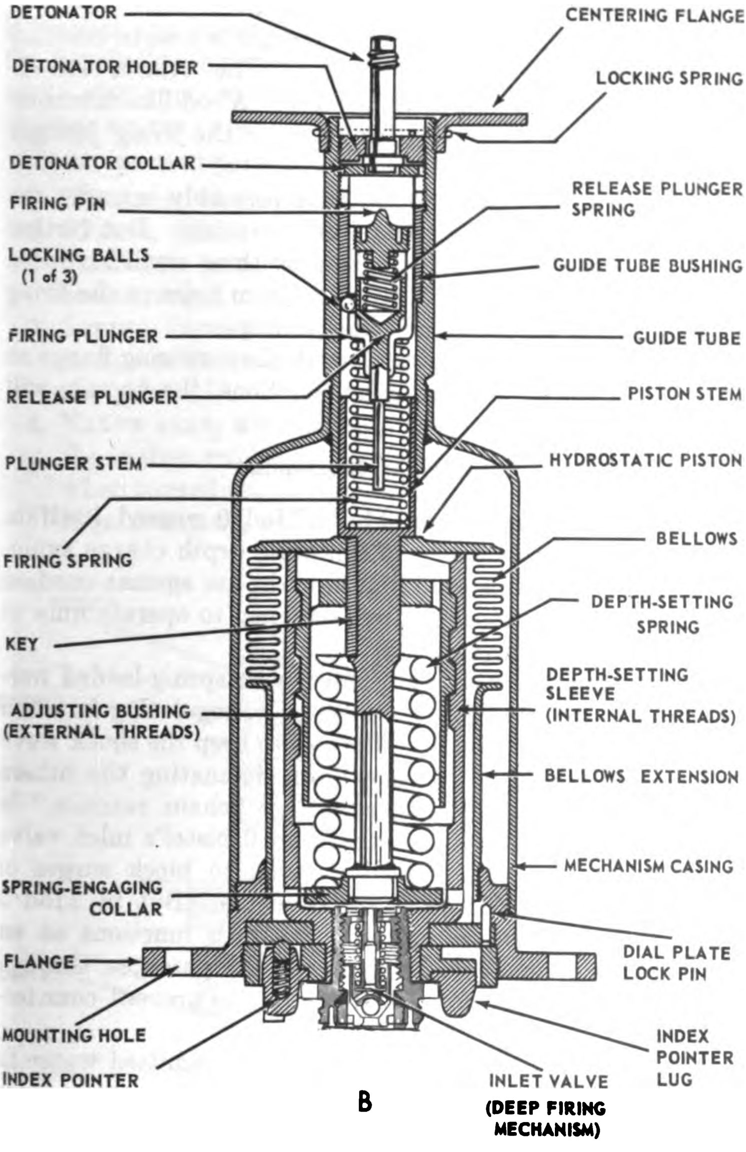


Figure 6–4.—Depth charge pistol Mk 6 Mod 2. B. Cross section.

on the FIRING PLUNGER. The plunger, in turn, can move inside a GUIDE TUBE BUSHING secured in the guide tube. A RELEASE PLUNGER inside the firing plunger is held in position by the RELEASE PLUNGER SPRING. The FIRING PIN is secured to the end of the firing plunger. A rod-like extension to the release plunger extends through the firing plunger toward the hydrostatic piston.

As you can see, the firing plunger assembly is under the continuous upward thrust of the firing spring. But further firing plunger movement is blocked by three small hardened steel LOCKING BALLS which protrude from holes in the firing plunger to engage the guide tube bushing.

The DETONATOR protrudes through the centering flange so that, when the booster extender functions, the booster will fit around it.

Deep-Firing Mechanism

The depth charge pistol Mk 6 Mod 0 proved itself in service as a reliable means of initiating depth charge explosion. But it had a severe limitation in use against modern deep-diving submarines—it was designed to operate only to 300-foot depths, maximum.

Mk 6 Mod 0 pistols were fitted with spring-loaded normally open inlet valves with no pressure-regulating function whatever. Their main function was to keep the shock wave of one depth charge explosion from detonating the others being dropped in the pattern. This "chain reaction" is called COUNTERMINING, and the Mod 0 pistol's inlet valve prevented it by automatically closing to block surges of water due to high-pressure shock waves. But in Mod 2 there is a DEEP-FIRING MECHANISM which functions as an inlet. It is designed with narrow interior passages, through which shock waves cannot easily surge, to prevent countermining.

The always-open inlet valve in Mod 0 admitted water to the pistol as soon as the depth charge submerged; since the pistol's hydrostatic mechanism is designed to function at a maximum of 300 feet, targets at greater depth could not be attacked. But in the Mod 2, the deep-firing mechanism can be set for deep targets so that it will not open until it reaches any preset depth ranging from 300 to 1,000 feet. Or, for shallower targets, the deep-firing mechanism can be set to stay open, so that the depth at which the pistol fires depends on the outer dial setting only.

The important parts of the deep-firing mechanism are the—

1. **Housing**, which screws into the nose end of the pistol.
2. **Spring**, which exerts upward thrust on the **valve assembly** (consisting chiefly of a **ball** and a partly hollow **stem**).
3. **Spring adjusting screw**, which is set to the proper compression before the mechanism is assembled to the pistol.
4. **Valve seat**, which screws inward to meet the ball of the valve on being turned clockwise (and outward when turned counterclockwise).
5. **Retainer nut**, which limits valve stem movement.

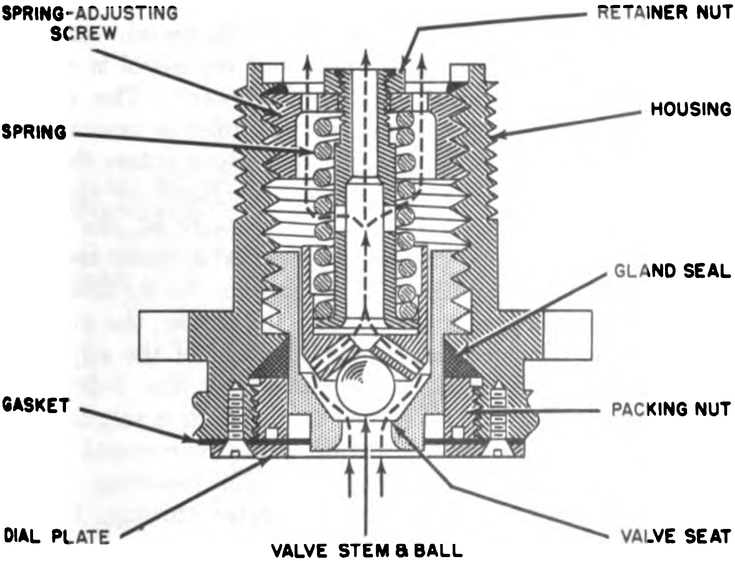


Figure 6-5.—Depth charge pistol Mk 6 Mod 2: Deep-firing mechanism.

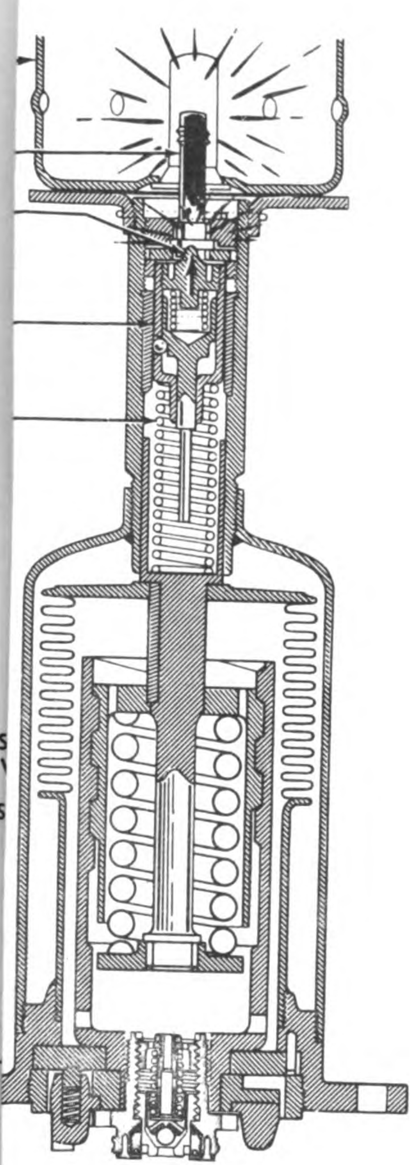
6. **Dial plate**, which shows the depth at which the mechanism is set to open.

In figure 6–5 the deep-firing mechanism for depth charge pistol Mk 6 Mod 2 is shown in its open position, as set for pistol functioning at depths shallower than 300 feet. The dotted lines show the flow of water past the valve ball and through the mechanism's interior. To set the mechanism for depths greater than 300 feet, the valve seat is screwed downward (by clockwise rotation) until it meets the valve ball and pushes it back against the thrust of the spring. The further down it is screwed, the greater the thrust of the spring against the ball—and the greater the water pressure required to overcome that thrust, to open the valve against the spring, and so to admit water to the pistol. The valve stays open when set for shallow firing because the retainer nut keeps the stem from following the valve seat all the way as the seat is set for such operation.

Functioning of Depth Charge Pistol Mk 6 Mod 2

Let us now follow the functioning of the pistol. Assume the deep-firing mechanism is open, and the pistol is set for the required depth (300 feet or shallower). The charge is launched; the safety cover over the inlet is removed at this point. As the depth charge sinks, water enters through the inlet (fig. 6–6, *A*) into the space enclosed by the bellows and hydrostatic piston. The pressure of the water quickly forces the hydrostatic piston and stem upward, until the spring-engaging collar encounters the depth-setting spring. (As you read a few paragraphs earlier, the point at which this occurs depends on the position of the adjusting bushing which, in turn, is regulated by the 0–300-foot depth-setting dial.) The higher the bushing is set, the less is the amount of "free" hydrostatic piston movement before the spring-engaging collar meets the depth-setting spring, and the slower is the piston's movement through the remainder of its stroke.

As the hydrostatic piston moves upward, it therefore com-



1 WATER ENTERS
THROUGH INLET
INTO
BELLOWS EXTENS
AND BELLOWS

presses both the depth-setting spring and the firing spring. (Fig. 6–6, *B*.) It also pushes upward the release plunger against its spring.

As you can see by examining figures 6–4, *B* or 6–6, *A*, the three locking balls are held in place by the sides of the release plunger. When the hydrostatic piston has pushed the release plunger far enough, its sloped sides can no longer hold the balls in place. (Fig. 6–6, *C*.) The firing plunger, now unlocked, can move upward under the thrust of its spring (fig. 6–6, *D*), the firing pin strikes the detonator, and the explosive train action starts.

When the deep-firing mechanism is set for functioning at any depth greater than 300 feet, this cycle of operation is delayed until the depth charge has sunk to the point at which the deep-firing mechanism valve opens. Otherwise, pistol functioning is as described.

The Mk 6 Mod 1 pistol, in Mk 9 Mod 3 depth charges—which may be issued to your ship for training purposes only—functions, in general, much as the Mk 6 Mod 2 does, but its deep-firing mechanism differs in details of construction from that of Mod 2, and can be set only to a maximum depth of 600 feet.

Setting Depth Charge Pistol Mk 6 Mod 2

To set the Mk 6 Mod 2 pistol for any depth 300 feet or less (as shown in fig. 6–7, *A*):

1. Remove the safety cover and see that the deep-firing mechanism pointer is set at the 0–300 foot mark on the INNER (deep-firing mechanism) dial. If it is not, set it by turning the pointer with a screwdriver (or the screwdriver end of the depth-setting wrench). Replace the safety cover.
2. Remove safe setting lock from outer dial index pointer. Using the depth-setting wrench as shown in figure 6–7, *C*, turn the pointer to the actual setting desired on its scale.

These two steps seem—and are—simple enough, but connected with them are two extremely important safety precautions:

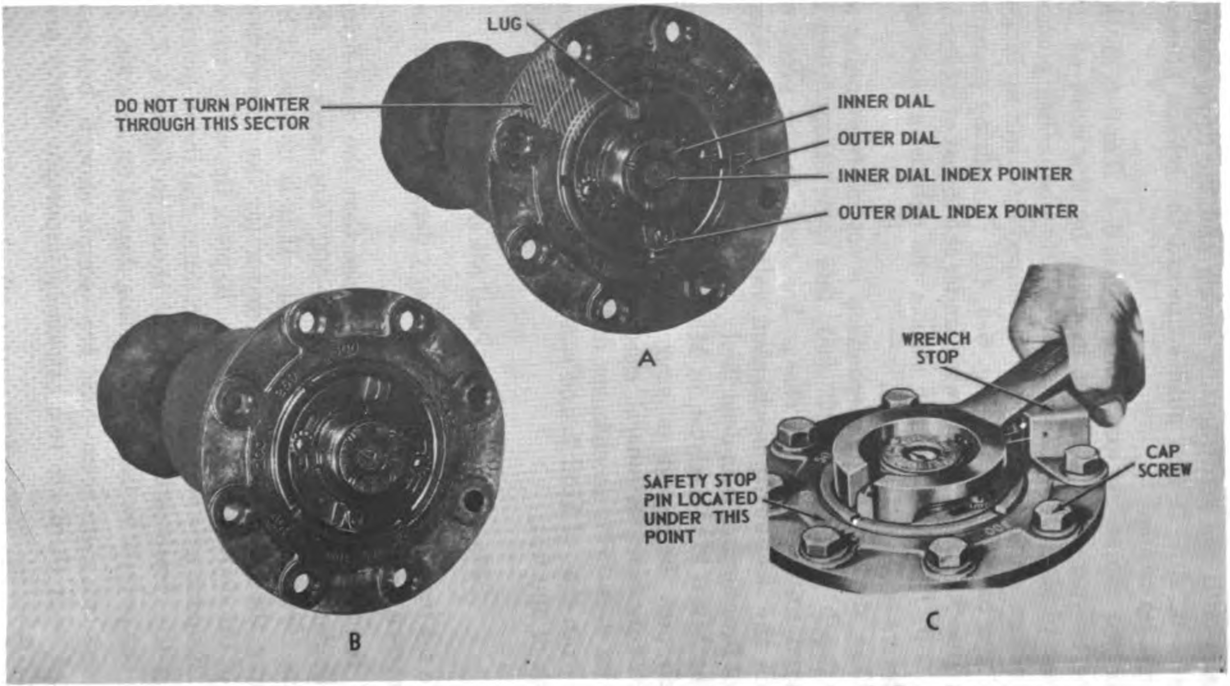


Figure 6-7.—Depth charge pistol Mk 6 Mod 2. A. Set for shallow fire. B. Set for deep fire. C. Using the depth-setting wrench.

1. If the deep-firing mechanism pointer is set for more than 300 feet, the inlet valve will be closed, and hydrostatic pressures at shallow depths will be insufficient to open it. This means that if the water is shallow the depth charge will never reach a depth at which it will go off, and it will be a dud so far as the immediate target is concerned. Worse, it will be a mine—a threat to navigation—while it remains unexploded on the bottom. So long as the valve and its gaskets don't leak, the depth charge will lie there without exploding. But once enough water has seeped in to operate the pistol—and that's just a matter of time—the charge will go off, and it will be just as dangerous to whatever is nearby as a mine would be. MORAL: For shallow firing, be SURE the deep-firing mechanism is at 0–300 position.

2. The outer pointer must NOT be turned through the sector between 30 and SAFE. A SAFETY STOP PIN under the dial plate is intended to prevent this, but because enough torque to shear the pin can be exerted by the depth-setting wrench, Mk 6 depth charge pistols are fitted with WRENCH STOPS (fig. 6–7, *C*) to prevent pointer movement through this sector.

NOTE. The stop is not shown in parts *A* and *B* of figure 6–7 because the pistols shown are not mounted in their charges; as part *C* shows, the stop is attached by the cap screws which secure the pistol to the depth charge casing.

In setting the pistol's outer dial, then, turn the wrench CLOCKWISE to the desired setting if the dial is set at 30 to begin with, and COUNTERCLOCKWISE if the dial has been set at SAFE. Do NOT attempt to turn the pointer from SAFE to 30, or the other way, by the shortest route. This is worth repeating here, and worth your repeating to your men, because turning the pistol's adjusting sleeve too far may cause the detonator to go off.

To set the Mk 6 Mod 2 pistol for any depth in excess of 300 feet (as shown in fig. 6–7, *B*), proceed as follows.

1. Remove the safe setting lock from the outer dial pointer. Using the depth-setting wrench, set the outer pointer to 100 feet on its scale.

2. Remove the safety cover. Using a suitable screwdriver (or the blade end of the depth-setting wrench), turn the inner pointer (on the deep-firing mechanism) to the desired setting. Here, too, avoid attempting to turn the index more than one complete turn; if the index is at either extreme setting, turn it back in the reverse direction without trying to force it past its normal stopping point. Then replace the cover.

Depth Charge Booster Extender Mk 6 Mod 2

As you remember from a preceding article, explosion of the detonator merely initiates the explosive train. The next step is to fire the booster.

If you look at figure 6–2 you can see that the booster has a cavity into which the detonator fits, but that the detonator and cavity are not close together—in fact, if the detonator were to go off while in this position, the booster would probably not be affected. How, then, does the detonator set off the booster?

The answer, as you know, is that the two are kept safely apart until the depth charge is actually in the water. Once the charge is in the water, a hydrostatic piston and bellows mechanism somewhat like that of the pistol pushes the booster down until the detonator is inside the detonator cavity. Let us look more closely at this BOOSTER EXTENDER MECHANISM. (Fig. 6–8.)

The principal parts of the Mk 6 booster extender are a—

1. Flange, which secures the mechanism in the central tube of the depth charge case
2. Watertight metal bellows, which houses the operating parts of the booster extender
3. Bellows guard, to protect the bellows
4. Bellows retainer (in Mod 2)
5. Piston
6. Spindle and spindle guide
7. Locking slide

The outer end of the bellows is secured to the inner side of the flange, while the piston is fastened to the inner end of the

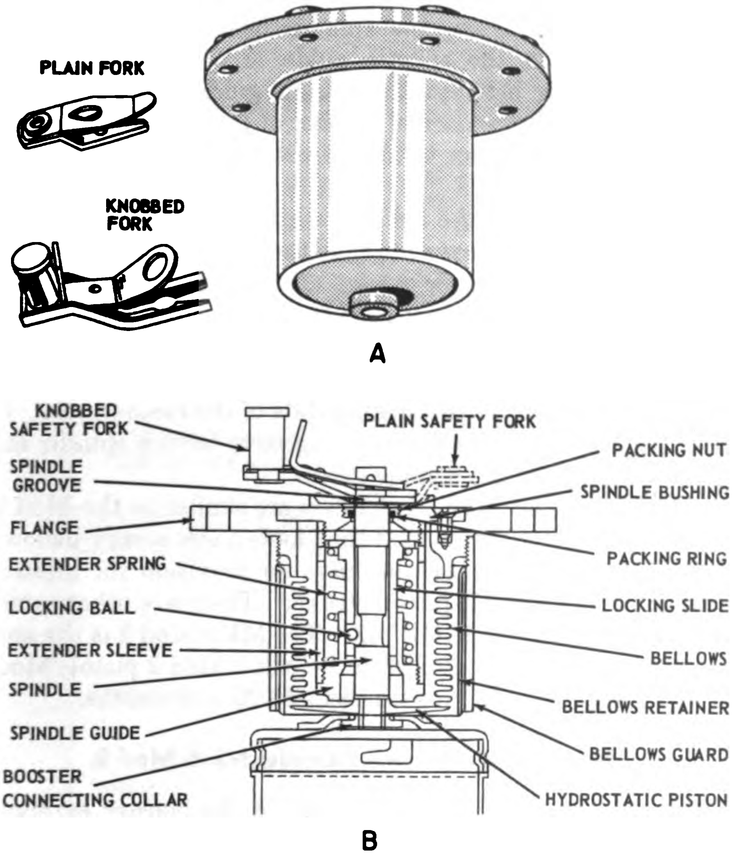


Figure 6–8.—Depth charge booster extender Mk 6 Mod 2. A. Exterior. B. Cross section.

bellows. A cup-shaped retainer is placed over the piston and bellows. A collar for attaching a booster can to the mechanism is mounted on the inner end of the mechanism and secures the bellows retainer in place.

The spindle, which extends outward through a bushing in the center of the flange, has a gently tapered section and an annular groove. (Fig. 6–8, *B*.) The tapered part ends in a shoulder. The spindle is attached to the piston.

An extender sleeve, secured to the inner side of the spindle guide, is mounted on the spindle bushing. The locking slide is between the spindle guide and the spindle. An extender spring between the spindle guide and the locking slide, along with the normal tension of the bellows, holds the mechanism in position until hydrostatic pressure is applied to it.

The outer end of the spindle, which projects through the spindle bushing, is grooved to take the safety fork which locks the mechanism safe prior to use. During shipment and storage and when the charge is fired from projectors, a plain fork is used; a knobbed fork replaces it when the charge is in a release track.

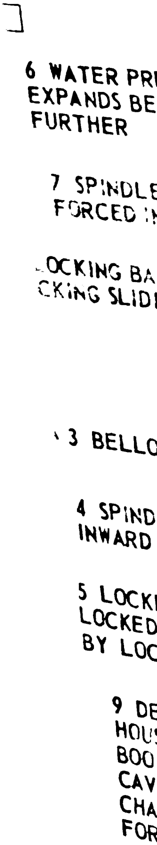
Locking balls fit in the locking slide of the mechanism. In safe position these balls fit in a groove in the spindle and are held there by the spindle guide.

The Mod 0 and Mod 1 extenders are similar to the Mod 2. The main differences are that they have a less sturdy bellows, lack certain water seals, and have no provision for limiting maximum hydrostatic piston stroke. There are other minor differences described in OP 747. The Mk 6 Mod 2 is the only extender that can be used with the Mk 6 Mod 2 pistol; Mods 0 and 1 are not built to withstand 1,000-foot depths.

Functioning of Booster Extender Mk 6 Mod 2

Now let us trace the functioning of the booster extender when the depth charge is launched. When the depth charge is dropped from a release track, the knobbed safety fork on the booster extender is stripped from the mechanism by a wiping plate on the track. If the charge is thrown from a projector, the plain safety fork is removed from the mechanism by hand before the projector is fired.

When the fork is pulled off the spindle, the bellows expands inward approximately one-fourth inch, moving the spindle inward through the spindle bushing. This carries the reduced diameter of the outer portion of the spindle into the opening in the bushing, leaving clearance around the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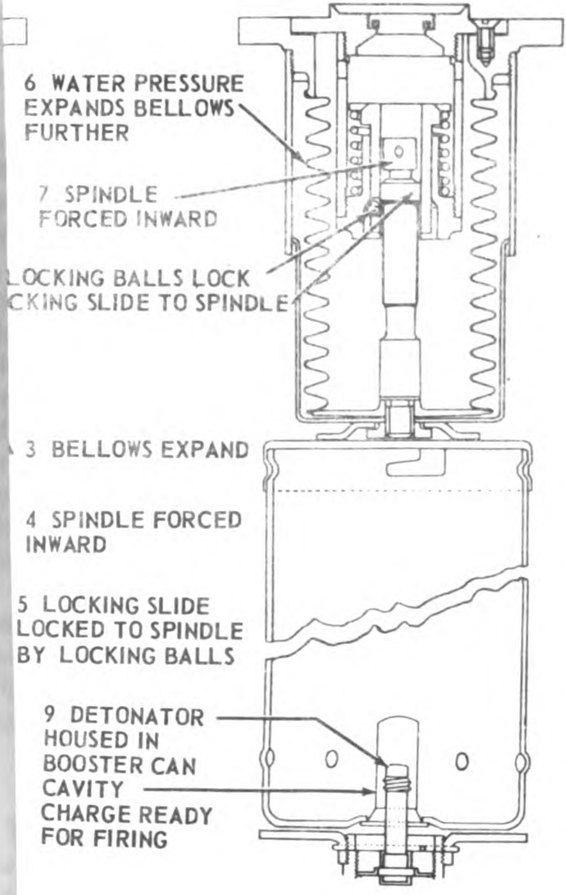
6 WATER PRESSURE EXPANDS BELLOWS FURTHER
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spindle through which water can enter the bellows. The spindle groove in which the locking balls rest is slightly elongated to provide for this initial motion of the spindle. (Fig. 6–9, *A* and *B*.)

As water enters the bellows, it forces the piston and spindle inward. Since the locking slide is locked to the spindle by the locking balls, the slide moves inward with the spindle against the thrust of the extender spring. When the spindle moves far enough inward to carry the locking balls into the enlarged section of the spindle guide, the balls slip outward into the guide, freeing the spindle from the locking slide. (Fig. 6–9, *C*.)

Now the only resistance to further inward motion of the piston is that of the bellows. Since this is comparatively light, hydrostatic pressure drives the piston downward toward the centering flange on the depth charge pistol until the detonator enters the cavity in the end of the booster can.

In Mk 6 Mod 0 and Mod 1 extenders, the hydrostatic piston pushes the booster until it meets the pistol centering flange. In Mod 2, however, the locking balls engage the shoulder at the large diameter of the spindle as the bellows approach full extension. The spindle then stops at the end of its travel because the balls are attached to the slide, which in turn, is held because its shoulder bears against the inner end of the guide. At full travel (fully armed position), the top of the booster can is about one-tenth inch from the pistol-centering flange. (Fig. 6–9, *D*.)

The booster extender mechanism requires no presetting before the charge is launched. It is only necessary to remove the safety fork to free the spindle at the time of launching. The extender is designed to reach its full travel by the time the depth charge has submerged from 11 to 25 feet.

Boosters and Detonators for Depth Charges Mk 9

The boosters currently used for Mk 9 depth charges are the Mk 6 Mod 2 and the Mk 6 Mod 4. Each booster contains about three pounds of granular TNT.

The Mk 1 Mod 1 instantaneous-action percussion detonators in these depth charges each contain 65 grams of mercury fulminate.

SAFETY FEATURES OF MK 9 DEPTH CHARGE

Before going into the stowage, handling, and maintenance of the Mk 9 depth charge, let us briefly review its external safety features. (Most of these have been mentioned earlier in this chapter; one has not yet been taken up.) Ninety percent of your dealings with Mk 9 charges will be concerned with these safeties, so they're worthy of special emphasis.

Beginning with the pistol, consider first the SAFETY COVER. There are two types: PLAIN and KNOBBED. (Figs. 6–3 and 6–10.) Except when the charge is in the launching track, the plain cover is used; the knobbed cover is substituted on charges in the launching track. Covers may be removed only for pistol adjustment, maintenance, or inspection, for changing depth setting, and (on charges in K-gun projectors) immediately before launching. The knobbed covers on charges in launching tracks break off on contact with the track framework as the charge rolls off the stern.

Next, the WRENCH STOP and SAFETY STOP PIN. The wrench stop mounts at the 200-foot mark on the pistol face, using the pistol's cap screws, when the pistol is installed in the charge. Figure 6–7, *C* shows how it limits wrench movement to protect the safety stop pin. The pin (which is not really an EXTERNAL safety), in turn, protects the depth-setting mechanism against over-rotation. (See figure 6–7 for the location of the pin; it is not visible on the pistol's face.)

Last (on the pistol), the SAFE-SETTING LOCK, which locks the pistol at SAFE despite the shock of gunfire, underwater explosions, or other accidents. (Fig. 6–10.) It is a narrow metal plate with a round hole at one end and a square one at the other. To mount it, you put the cap screw at the "30" outer dial mark through the round hole, engage the outer index pointer (set at SAFE) with the square hole, and

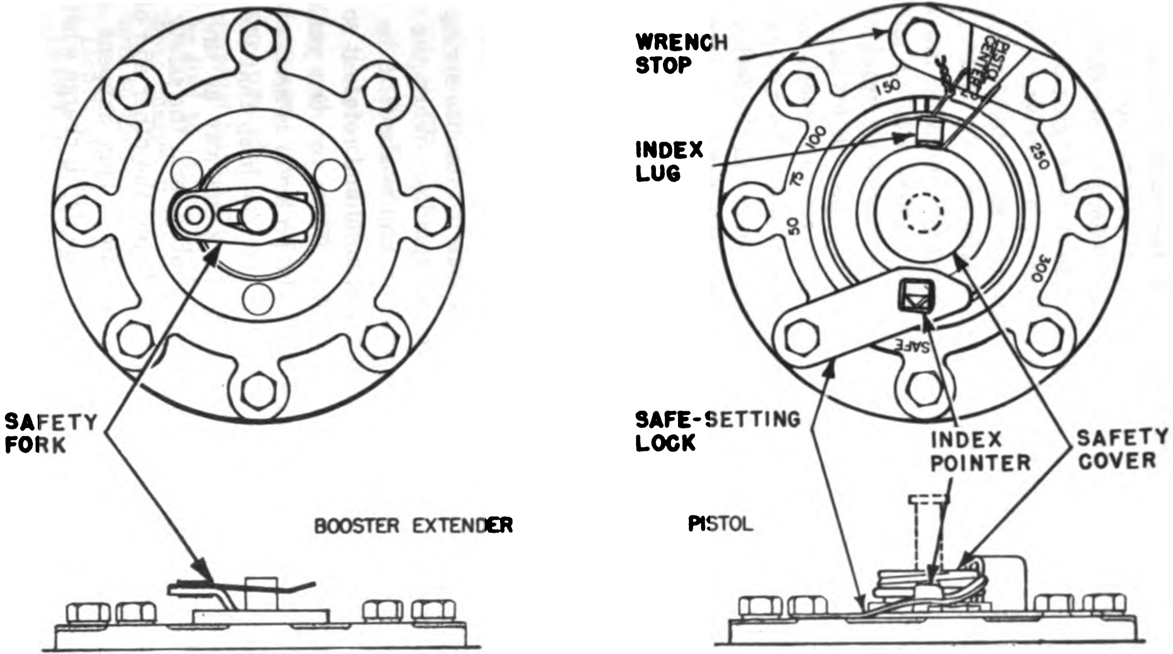


Figure 6-10.—Safety features of Mk 9 depth charges.

tighten the cap screw. To release the lock, just pull the tapered end up and rotate it off the index pointer. If the lock is for some reason not available, you can improvise a safe-setting lock by reeving No. 19 copper wire through the hole in the index lug and the wrench stop, as figure 6–10 shows. When you make the depth setting with the wrench, the wire will break; it need not be removed or cut beforehand.

Now for the booster extender safety. (Fig. 6–10.) This is the SAFETY FORK, which prevents extender movement while it is engaged. The PLAIN fork is used at all times except when the charge is in the launching track; in the track, the KNOBBED fork (which is wiped off by part of the track structure as the charge rolls off the track) must be substituted. When the charge is mounted in a K-gun, you attach a lanyard to the plain fork, and pull the fork off just before firing. (You, or the crewman assigned, must pull it off; current regulations prohibit attaching the free end of the lanyard to the ship's structure for this purpose.)

Early designs of safety forks sometimes were knocked off booster extender spindles by the shocks of detonations nearby—even those of the ship's own depth charges going off overboard. Present designs therefore have safety locks to prevent this. (Fig. 6–8, *A*.)

On the plain safety fork this lock is a bronze spring with a hole that engages the extender spindle. When the depth charge is loaded on the projector, and is about to be fired, you lift the spring clear of the spindle and rotate it so that it no longer engages the spindle. Then you can yank the fork off with the lanyard when the projector is fired.

On the knobbed fork there is a safety hasp that fits over the extender spindle in much the same way as the plain fork's spring. To unlock the knobbed fork, the safety hasp upper part is forced against the knob; the other end of the hasp then lifts clear of the spindle. This happens automatically as the fork is wiped off the depth charge when the charge is launched.

HANDLING AND STOWAGE OF MK 9 DEPTH CHARGES (COMPLETE ROUNDS)

Mk 9 type depth charges must be stowed and handled carefully. Uncrated charges must be battened down during stowage or shipment to prevent movement. Recommended stowage consists of placing the charges upright on nose or tail in one or two tiers separated by a platform. Movement must be restricted. Racks are approved for horizontal stowage if vertical and horizontal movement is not excessive.

It is important to prevent damage to the support rings. Any deformation to the rings may cause charges to jam in the release tracks. Inspect the charges for damage before loading into release tracks. If a charge or ring is deformed but not badly damaged, it should be launched from a projector rather than from a release track. Remove pistols and boosters from the depth charges upon entering port, if operationally practicable.

Depth charges in ready stowage in launching tracks should comply with the following requirements:

1. Depth charge assemblies complete with pistol, detonator, and booster extender installed.
2. Knobbed safety covers in place on pistol.
3. Knobbed safety forks in place on booster extender.
4. Depth setting made as prescribed by gunnery officer or ASW officer.

For certain conditions which hinder normal operation of tracks, such as severe icing or damage to track release mechanisms, your gunnery officer may require changes from regular procedure. Normally, knobbed safety forks and covers must be stripped by the wiping plate only and should not be tied to the racks or anything else.

Depth charges in ready stowage in K-gun projectors should conform to the following requirements:

1. Depth charge assemblies complete with pistols, detonators, and booster extenders installed.
2. Deep-firing mechanism valve cover removed (only for immediate firing).

3. Plain safety fork in place on booster extender, with a short (1-foot) lanyard attached for removal by hand. Lanyard is attached ONLY to safety fork; other end must be free.
4. Depth setting made as prescribed by gunnery officer or ASW officer.

HANDLING AND STOWAGE OF MK 9 DEPTH CHARGE COMPONENTS

Depth charge components are generally shipped separately. Manufacturing specifications require each pistol and booster extender mechanism to be packed in a separate corrugated paper carton and shipped in substantial wooden boxes, ten pistols or extender mechanisms to a box. Reshipment from depots is made in the original cartons and boxes when practicable.

The flanged central tube openings of cases, both empty and loaded, should be closed with gaskets and metal shipping covers when in storage or in transit.

Detonators are packed six to a metal container. Two metal containers are enclosed in a wooden box.

Loaded boosters are packed twenty-five to a wooden box for shipment.

Pistol stowage boxes and booster stowage cans are used for stowing depth charge components aboard ship. When the pistol without detonator is stowed separately, the outer index pointer should be set at "300" and the plain safety cap should be in place. When the booster and extender are stowed separately, the plain safety fork should be on the extender spindle.

DAILY AND WEEKLY UPKEEP ROUTINES FOR MK 9 DEPTH CHARGE

Daily upkeep routine for Mk 6 Mod 2 pistols installed in Mk 9 depth charges in ready stowage is as follows:

1. Rotate outer index pointer from present setting to "30"; next, clockwise from 30-foot mark to SAFE; then counter-

clockwise from SAFE back to depth setting prescribed by gunnery or ASW officer.

2. Remove safety cover and turn index pointer of deep-firing mechanism from present setting to "0–300," then full-scale clockwise from "0–300" to "1,000." Finally, turn pointer counterclockwise from "1,000" to depth setting prescribed.
3. Examine safety covers before replacing. If any are defective in the slightest respect, get new ones. Screw covers on tightly when replacing, using the proper wrench.

Weekly upkeep routine for Mk 6 Mod 2 pistols when installed in Mk 9 depth charges in ready stowage is similar, except that a few drops of light oil (such as N. S. 2110) should be applied to the surface between the outer index pointer and the dial plate, and around the index pointer plunger.

When the charges are set at SAFE, the weekly upkeep procedure is as follows:

1. Apply a few drops of light oil on surface between outer index pointer and dial plate and around index pointer plunger. Disengage safe-setting lock. Rotate outer pointer counterclockwise from SAFE to 30-foot mark.
2. Turn index pointer clockwise back to SAFE. Reset safe-setting lock.
3. Remove safety cover and rotate index pointer of deep-firing mechanism counterclockwise from "1,000" to "0–300."
4. Turn index pointer of deep-firing mechanism clockwise from "0–300" back to "1,000" and replace safety cover.
5. Examine safety covers. If any are defective, replace them. Make sure that covers are screwed on tightly.

Caution: NEVER attempt to rotate index pointer clockwise from SAFE to 30-foot mark, or counterclockwise from 30-foot mark to SAFE. This may shear off index pointer stop pin.

Daily upkeep routine for booster extender mechanisms in Mk 9 depth charges in ready stowage is as follows:

1. Remove the safety fork. (Hook the extender testing tool into the eye of the fork to do this.) When the fork is off, the spindle should move inward about one-fourth inch. If the spindle fails to move inward, because of tightness of the seal, back off the packing gland approximately a quarter turn. Don't overdo it, or the gland seal will no longer seal effectively.

2. Engage the testing tool hook in the hole at the end of the spindle. Pull outward. Hold the spindle in this position and swing the body of the tool until the recessed end engages in the spindle groove. Release the tension on the tool. The booster spindle will retract and pull the body of the tool into the hole in the spindle bushing. The hook will now be free; swing it outward to clear the flange. Before releasing the tension on the tool, be sure that it is centered on the spindle so that its edge does not gouge the seal as it goes into the hole.

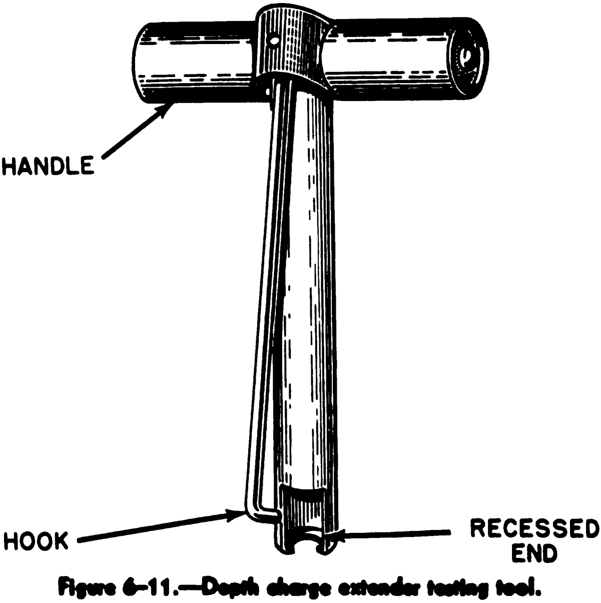


Figure 6-11.—Depth charge extender testing tool.

3. Test the booster for freedom of motion by pushing the spindle inward NOT MORE THAN three-fourths inch.

4. The spindle tends to resist motion because of the reaction of the spring and friction of the locking balls. But if there is binding or excessive resistance, examine the booster can, central tube, and exterior of the extender mechanism. If you cannot readily locate and correct the difficulty, return the extender for overhaul.

5. To release the tool from the booster spindle, swing the hook into the spindle hole. Pull outward on the hook, and disengage the body of the tool from the groove. Swing the body of the tool outward and away from the spindle, and replace the safety fork. Remove the hook.

SAFETY NOTE. Because considerable effort is required to pull the spindle out of the extender after the plain-type safety fork has been removed, see that your men take safety precautions when performing these operations on the aftermost depth charges in release tracks which, on some ships, overhang the stern on the outboard side.

SHIPBOARD ASSEMBLY OF MK 9 DEPTH CHARGE COMPONENTS

Since depth charges are issued to ships as separate components, it is up to shipboard personnel to assemble and adjust the components into serviceable complete rounds. In this section we shall take up the procedure for assembling boosters, booster extenders, pistols, and detonators into Mk 9 depth charge cases, and testing and adjusting them as required. This should be done only for charges stowed topside in stowage racks, releasing tracks, or projectors.

NOTE. Before assembling any components to make up a complete depth charge, check EACH PART to see that it bears a depot inspection tag or stencil. This marking ensures that the component was in good working order when shipped.

Installing Booster and Extender

Now let us begin with installation of boosters and booster extenders. They go into the TAIL of the depth charge central tube. This installation must be done BEFORE the pistol and detonator are installed. Here is the procedure:

1. Make sure a safety fork is in place on the spindle of the booster extender.
2. Remove the blanking plate and rubber gasket from the tail of the depth charge case central tube.
3. Clean the booster extender flange, the flange on the central tube, and the rubber gasket. They must be free of dirt and grease. The gasket must be in good condition.
4. If the booster and booster extender are not already assembled, engage the socket on the booster can with the collar on the booster extender.
5. Insert the booster and booster extender in the central tube of the case with the rubber gasket between the flange on the central tube and the booster extender flange.
6. Place the cap screws with lock washers in the flanges. Tighten the screws gradually, one by one, until all are uniformly tight. If you do not tighten all the screws equally, the booster extender may be slightly cocked in the central tube. This may cause faulty operation of the mechanism or may allow leakage into the central tube.
7. Finally, check the booster extender as described in the article above on daily upkeep routine for booster extenders.

Installing Pistol and Detonator

With the booster and extender properly installed and tested, the next step is to install the detonator and pistol into the NOSE of the depth charge. Here is the procedure:

1. Remove the safety cover and inspect the orifice of the deep-firing mechanism. Set the deep-firing pointer at "0–300." Replace the safety cover.

2. Check to see that the pistol is cocked. To do this, turn the pistol so that the detonator end faces you. In a

cocked pistol, the firing pin is well inside the guide tube, and will not yield when you try to push it inward. In an uncocked pistol the firing pin is practically at the end of the tube, and will yield when you push at it. To cock the pistol, first release entrapped air. Be sure the deep-firing mechanism is set at 0–300, which opens the inlet valve. Then push the firing pin inward carefully with a rod or long tool, like a screwdriver, as far as it will go. It should stay in cocked position when you remove the cocking tool. If it doesn't stay cocked, try two or three times more. If it still won't cock, turn the pistol in for overhaul.

3. Rotate the index pointer from SAFE to "30" (counterclockwise) and back again (clockwise), using the depth-setting wrench. If it fails to make full-scale rotation without binding, or if the firing pin releases around the "50" mark, the depth-setting sleeve is assembled improperly, and the pistol requires overhaul.

4. If the depth-setting mechanism checks out OK on step 3, try to turn it BY HAND clockwise from "30" or counterclockwise from SAFE. If the index pointer turns through the narrow sector between SAFE and "30" without appreciably more resistance than through the rest of the scale, the safety stop pin is sheared, and the pistol should be set aside for overhaul. If the pin is OK, the pointer will not turn through this sector. Don't use a wrench in making this check; it is not difficult to shear the pin with a wrench, but not many men can shear it with their bare hands. When you finish with the depth-setting mechanism, it should be set at SAFE.

5. Release the detonator holder locking spring and remove the detonator holder with the detonator holder wrench.

6. Place the detonator in the detonator collar. Lower the detonator holder over the detonator and screw it in place with the detonator holder wrench. Replace the locking spring. See that the end of this spring projects inside of the guide tube to prevent the detonator holder from backing out.

SAFETY NOTE. The detonator is very sensitive. It must ALWAYS be handled with extreme care.

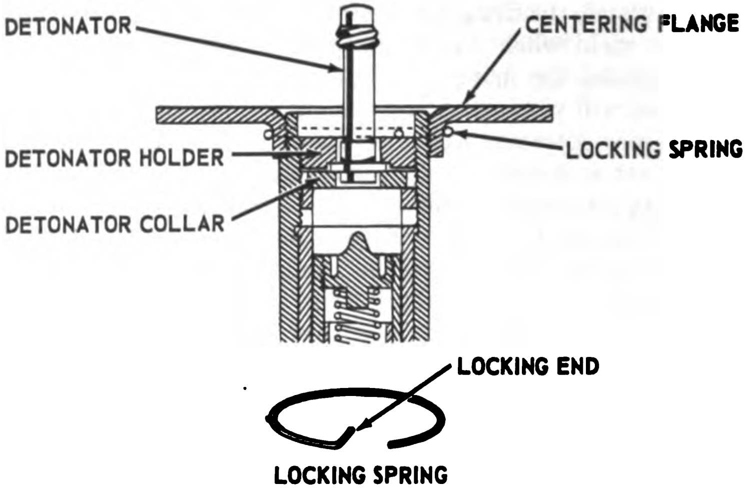


Figure 6-12.—Depth charge pistol Mk 6 Mod 2: Detail of detonator end (cross section).

7. Remove the blanking plate and rubber gasket from the nose end of the depth charge central tube.

8. Clean the pistol carrying flange, the flange on the central tube, and the gasket. They must be free of dirt and grease, and the gasket must be in good condition.

9. Place the gasket on the central tube flange or slip it over the centering flange of the pistol and hold it against the pistol carrying flange. Then insert the pistol in the case.

10. Put the securing cap screws and lock washers in place in the flanges. Locate the safety stop for the depth-setting wrench by placing its attaching cap screws in the pistol carrying flange holes adjacent to the "150" and "250" dial marks. The stop is marked to indicate its orientation.

11. Slip the square-holed end of the safe-setting lock over the index pointer. Secure the other end to the pistol carrying flange with the cap screw and lock washer adjacent to the "30" dial mark.

12. Set up the cap screws until all are uniformly tight.

Caution: Keep the depth-setting dial of the pistol on SAFE, and the safe-setting lock in place at all times, until the pistol is adjusted for immediate use. When the depth settings are specified by the responsible officer, safe-setting locks may be released and the setting dials turned to the desired positions.

QUARTERLY INSPECTION TEST AND MAINTENANCE PROGRAM FOR MK 9 DEPTH CHARGE COMPONENTS

The assembly, maintenance, and testing procedures for Mk 9 depth charge components described so far in this chapter are those that shipboard personnel on combat vessels can be reasonably expected to perform. But both pistols and booster extenders must be tested by actual subjection to pressures equivalent to those they will encounter in service, and must be calibrated so that they will function in accordance with their depth scales and rated characteristics. Such testing and calibration, as well as complete overhaul and major repair, can be performed only with the aid of equipment not available aboard most combat ships.

To do this kind of work, the Navy has set up a system of MAIN STATIONS, SECONDARY STATIONS, and OVERHAUL STATIONS, which are equipped with testing machinery and repair facilities. Once every three months, forces afloat turn in to the appropriate secondary station or main station their depth charge pistols Mk 6 Mod 2 and their booster extenders Mk 6 Mod 2 for check and (if necessary) recalibration and adjustment or repair. Briefly, this check includes verifying the pressures required to fire the pistol at 30-foot and 100-foot depth settings, verifying deep-firing mechanism functioning at 600-foot settings, ascertaining the pressure required (equivalent to a depth between 11 and 25 feet) for the booster extender mechanism to function, and checking the watertightness of these assemblies. The pressures equivalent to these depths are produced by a Mk 3 test set.

Repairs, recalibrations, and other adjustments as required may be performed by either main or secondary stations; main stations are more fully equipped. At present, every naval section base, submarine and destroyer base, and mine depot that inspects Mk 9 depth charge equipment is designated as a secondary station, except for a few that have been designated as and equipped to be main stations. Overhaul stations, of which there are two (Yorktown Naval Mine Depot in the East and Hawthorne Naval Ammunition Depot in the West), perform complete reconditioning of components and inspection of new material. Destroyer tenders are also equipped with test sets for performing the quarterly checks of Mk 9 depth charge pistols and booster extenders.

Current directives still prescribe monthly, rather than quarterly, inspections for depth charge pistols and booster extenders earlier than Mk 6 Mod 2. Since few such are now in service, it isn't likely that you will have to worry about them.

If you are stationed aboard a destroyer tender or one of the types of stations charged with test and overhaul of pistols and booster extenders for Mk 9 depth charges, you should study OP 747, OP 866, and their changes for details on overhauling and testing.

OPERATIONAL CHARACTERISTICS OF MK 9 DEPTH CHARGE

As a Chief Gunner's Mate or Gunner's Mate First Class, you may be assigned to assist the ASW officer in supervising the launching of depth charges in antisubmarine attacks. You are already well acquainted with the main principles of the depth charge attack. To apply your knowledge of these principles to the actual operations of a depth charge attack, you must be acquainted also with the operational characteristics of the Mk 9 depth charge.

A major operational characteristic of a depth charge is its SINKING SPEED. The terminal sinking speed of Mk 9 depth charges is 23 feet per second. (TERMINAL sinking speed refers to the fact that the rate at which the charge sinks is, after the first few feet of underwater travel, the same regardless of its velocity when it entered the water. Terminal speed is the constant sinking rate of the charge.) This sinking speed may be used in attack calculations without introducing significant errors if a WAKE TIME allowance of one-half second is made for charges dropped from release tracks. (It takes that much longer for a track-launched charge to attain full sinking speed.) No wake time need be allowed for depth charges launched from projectors, as the charges will strike the water with velocities greater than their terminal velocity in water. Approximate sinking times of track-launched charges are: 3 seconds to 50 feet, 5 seconds to 100 feet, and 7 seconds to 150 feet. If spoiler plates are used, the terminal speed will be reduced to 15 feet per second.

Charges Launched From Tracks

When charges are launched from stern tracks, sinking speed is important not only in making the actual attack but also for determining the minimum safe speed of the attacking vessel. For example, when charges are launched successively from one track, the shocks of the detonating charges repeatedly jar the ship's stern, including especially the launching tracks themselves. In the track not being used for launching, the parts of the depth charge rings that are in contact with the track must repeatedly absorb each shock. The shocks of a succession of charges from one track, detonating close astern and at shallow depths, can in this way damage seriously the charges standing in the other track.

The way to avoid this damage is to launch charges alternately from each track (this keeps the charges on both sides rolling so that the shocks are not concentrated on any one part of the depth charge rings), and to maintain minimum ship speeds that will get the stern safely clear of the area by the time the shallowest firing charges launched will detonate. Figure 6–13 shows the minimum speed at which all present Mk 9 charges (curves *A* and *B*) may be safely launched FROM A SINGLE TRACK when set so as to detonate at depths between 50 and 250 feet.

How do you use this chart?

Here is an example: Assume Mk 9 Mod 4 depth charges, being launched from a single track, set so as to detonate at 75 feet. The curve shows that ship speed must be AT LEAST 16 knots.

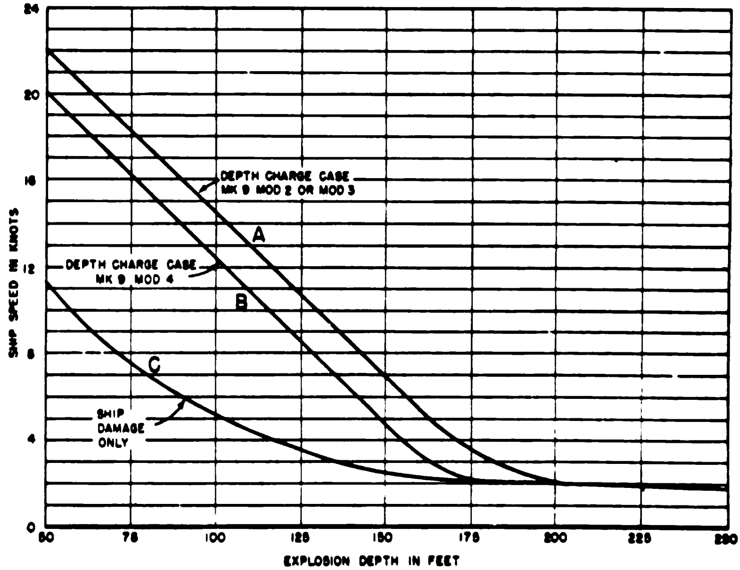


Figure 6–13.—Depth charge Mk 9: Minimum safe launching speeds.

Curves *A* and *B* are based on the use of charges in good condition. Frequent inspections should be made and defective cases replaced. The minimum safe speed for charges using depth charge cases Mk 9 Mod 4 is less than for charges using the Mk 9 Mod 2 and Mod 3 cases because of the greater strength of the Mod 4 case.

Curve *C* represents the minimum below which ship speed should never fall if ship damage is to be avoided. Curve *C* is for normal conditions, and the speeds given are specified to protect the ship from structural damage or severe shock damage. Minor shock damage, such as electrical troubles, which will not permanently immobilize the ship or seriously impair her activities, MAY develop at these speeds. However, it may be necessary to take some risk by dropping charges at slower than the minimum safe speed if the situation seems to require it to deliver a promising attack against an enemy submarine.

TABLE 1

ACTUAL FIRING DEPTHS OF DEPTH CHARGE PISTOLS MK 6 MOD 1 AND MOD 2 IN DEPTH CHARGES MK 9 MOD 2, MOD 3, AND MOD 4 (± 10 PERCENT VARIATION)

Depth Charge Pistol	Pistol Depth Setting (feet)	Firing Depth [1]
Mk 6 Mod 1		
(Range 30–600 feet)	30	110
	50	130
	75	155
	100	170
	150	195
	200	210
	250	250
Mk 6 Mod 2		
(Range 30–1,000 feet)	30	60
	50	70
	75	85
	100	105
	150	150

[1] Firing depths greater than those indicated conform with pistol depth settings.

TABLE 2

NORMAL RANGES AND ESTIMATED TIMES OF FLIGHT FOR PROJECTED DEPTH CHARGES MK 9 MOD 2, MOD 3, AND MOD 4

Impulse Charge	Range (yards)	Estimated Time of Flight (seconds)
No. 1 (14 oz.)	60	3. 4
No. 2 (20 oz.)	90	4. 2
No. 3 (28 oz.)	150	5. 1
No. 4 (8¾ oz.)	35	2. 6
No. 5 (14+ oz.)	70	3. 6

Following are several qualifications which modify the application of these curves.

1. At shallow depths, the actual depth at which the charge explodes is greater than that set on the pistol. The amount of this discrepancy is shown (within ±10 percent) in table 1. Thus, to get a Mk 9 depth charge with Mk 6 Mod 2 pistol to fire at 75 feet, you should set the pistol at a shade over 50 feet.
2. If charges are dropped from each track alternately, instead of from one track only, speeds shown by curves *A* and *B* may be reduced by 4 knots.
3. If spoiler plates are used, ship speeds (all three curves) may be reduced 4 knots because of the lower sinking speeds of charges with spoiler plates.
4. In practice attacks or for depth charge testing, the launching speed should be at least 2 knots greater than that specified for normal service.
5. In water under 100 feet deep, raise the minimum speed by 2 knots because of the likelihood of reflection of the shock wave from the bottom, with increased damaging effect.

Projected Charges

Under normal conditions, when launching depth charges from K-gun projectors using No. 1 impulse charges, no minimum ship speed is prescribed; however, it is standard practice to observe minimum safe launching speeds as for stern-dropped charges. Depth charges launched from projectors with No. 1 impulse charge may not be safe if the impulse charge gives appreciably less than 50 yards range for any reason, such as excessive rolling or improper impulse charge functioning.

Table 2 gives the normal ranges and estimated times of flight for projected depth charges Mk 9 Mod 2, Mod 3, and Mod 4.

Launching Charges Under Abnormal Conditions

Under abnormal conditions, somewhat higher minimum speeds may be adopted to avoid serious damage to the firing ship. The speed margin to allow can be determined only by the best judgment of the commanding officer. A convenient formula to use in reckoning safe speed is: ship's speed in feet per second (1 kt=1.7 fps), multiplied by sinking time, equals increase in horizontal distance of explosion from ship. Thus, with a 7-second sinking time, 2 knots additional speed will give about 3.4×7=24 feet increased distance from the ship.

The abnormal conditions which will require higher speeds are—

1. Rough weather and heavy seas.
2. Structural damage to the ship.
3. Shallow water.

Rough weather and heavy seas not only impose high stresses on the ship's structure but also slow the ship below the speed indicated by propeller rpm. Great care is needed in estimating speed through the water, by pitometer log or by eye, to ensure that the ship is actually making good the desired speed.

If the ship has already suffered damage, whether depth charges should be dropped at all will depend on the specific damage and tactical situation. If depth charges are dropped, very liberal speed allowances should be made to avoid further hull damage.

Depth charge pistols Mk 6 and Mods were originally designed for use in the old depth charges ("ashcans") of the Mk 6 and Mk 7 types, which do not sink as fast as the streamlined Mk 9 type. The faster-sinking charges do not permit sufficient time for the water chambers of these pistols to fill for firing at shallow depths. This is the cause of the discrepancy, already noted, between the depth settings and actual depths of explosion. Table 1 shows the depths at which pistols will probably fire when used in Mk 9 depth charges (without spoiler plates).

SUMMARY

In this chapter we have taken up the standard hydrostatic depth charge now used in the Fleet—the Mk 9—and its main components. We have studied its construction, principles of operation, methods of assembly and adjustment on shipboard, and shipboard maintenance, as well as the operational characteristics of the complete round when launched or projected.

For details on the launchers and projectors used with Mk 9 depth charges, see chapter 8.

If you are assigned to duty at a main, secondary, or overhaul station and are charged with testing of depth charges, you will have to know much more than is presented in these pages. See OP 747 and OP 866 and their changes for full information on testing and reconditioning of depth charges and their components. If you need further information on Mk 6 and Mk 7 depth charges, see OP 747.

In the next chapter, you will study a depth charge which resembles the Mk 9 externally, is launched the same way, and has most of the same operational characteristics, but is quite different in its functioning. For further details on the Mk 14 depth charge, turn to chapter 7—but before you do, be sure to work the quiz on this chapter that you have just finished.

QUIZ

In each of the following, select the BEST answer.

1. The function of the spoiler plate, when installed in a Mk 9 depth charge, is to
    a. increase blast effect
    b. reduce dispersion
    c. reduce sinking speed
    d. increase sinking speed
2. During shipment and stowage, a Mk 6 depth charge pistol's inlet valve must be protected by a
    a. plain safety cover
    b. knobbed safety cover
    c. plain safety fork
    d. knobbed safety fork
3. In the Mk 6 depth charge pistol, the adjusting bushing is keyed to the
    a. centering flange
    b. depth-setting sleeve
    c. piston stem
    d. deep-firing mechanism

4. In the Mk 6 depth charge pistol, moving the outer index pointer raises or lowers the
   - a. depth-setting sleeve
   - b. adjusting bushing
   - c. hydrostatic piston
   - d. firing spring

5. In the Mk 6 depth charge pistol, the spring-engaging collar is attached to the
   - a. depth-setting mechanism
   - b. depth-setting spring
   - c. firing spring
   - d. piston stem

6. The main difference between the Mk 6 Mod 0 depth charge pistol and later mods is that the Mod 0 lacked
   - a. a deep-firing mechanism
   - b. an anticountermining device
   - c. an inlet valve
   - d. a depth-setting mechanism

7. Which of the following BEST describes countermining?
   - a. The shock wave of an underwater explosion sets off other explosions
   - b. Small mines are used to set off depth charges
   - c. Hydrostatic pressure is used to actuate depth charge explosive trains
   - d. The explosion of one depth charge neutralizes the shock waves produced by other underwater explosions

8. The deep-firing mechanism in the Mk 6 Mod 2 pistol will stay open when the depth charge is set to go off at
   - a. 1,000 feet
   - b. 600 feet
   - c. 400 feet
   - d. 200 feet

9. As the Mk 9 depth charge sinks through the water, which of the following springs in the Mk 6 pistol does NOT move as a result of hydrostatic piston movement?
   - a. Release plunger spring
   - b. Deep-firing mechanism spring
   - c. Depth-setting spring
   - d. Firing spring

10. When the Mk 6 Mod 2 depth charge pistol is to be set to fire at 800 feet, the outer dial index pointer should be set at
    - a. 100
    - b. 800
    - c. 0–300
    - d. SAFE

11. In the Mk 6 Mod 2 booster extender, when the safety fork is pulled off the spindle,
    a. water rushes into the bellows
    b. the spindle moves inward about one-fourth inch
    c. the booster moves far enough to surround the detonator
    d. the locking balls free the spindle from the locking slide

12. The standard safe-setting lock on the Mk 6 depth charge pistol
    a. locks the hydrostatic piston
    b. holds the wrench stop at SAFE
    c. engages the outer index pointer
    d. keeps the deep-firing mechanism inlet closed

13. Which of the following is NOT a requirement for Mk 9 depth charge assemblies in ready stowage on launching tracks?
    a. Deep-firing mechanism safety cover removed
    b. Knobbed safety fork substituted for plain fork
    c. Knobbed safety cover substituted for plain cover
    d. Depth setting made as prescribed by ASW officer

14. The proper time to install the booster and extender in a Mk 9 depth charge is
    a. before the charge is put into ready stowage topside
    b. after the safety fork has been removed
    c. after the pistol is installed
    d. before the pistol is installed

15. Depth charge pistols Mk 6 Mod 2 and booster extenders Mk 6 Mod 2 must be turned in to secondary or main stations for check and recalibration every
    a. 2 weeks
    b. 1 month
    c. 6 weeks
    d. 3 months

16. The terminal sinking speed of a Mk 9 depth charge is
    a. 15 feet per second
    b. 23 feet per second
    c. 50 feet per second
    d. dependent on whether it is fired from a projector or launched from a track

There are no choices for the following question; just figure it out.

17. Using the information presented in this chapter, what would you recommend as the minimum ship speed for launching TNT-loaded Mk 9 Mod 4 depth charges alternately from either launching track in a practice attack? Assume minimum depth of water is 300 feet; minimum depth setting is 50 feet; other conditions are normal.

    NOTE TO STUDENT. This minimum depth setting is NOT the depth at which the depth charge so set will detonate. In figuring actual detonation depth, assume that Mk 6 Mod 2 pistol is used.

CHAPTER 7

INFLUENCE-TYPE DEPTH CHARGES

INTRODUCTION

In the preceding chapter we took up the hydrostatic depth charges now in use in the U. S. Navy. But, in spite of the introduction of new A/S weapons (taken up in chapter 8) which are based on principles radically different from those of hydrostatic depth charges, further development to improve the depth charge itself still continues. And one of the fruits of that development has been the Mk 14 depth charge.

The Mk 9 hydrostatic depth charge is an effective A/S weapon of its kind. If it detonates anywhere near a submarine, that submarine is a goner. But that's the heart of the problem—making it detonate near the target. It's not easy. Our modern sonar can locate its targets accurately, but only within rather broad limits—and even sonar instruments don't come with crystal balls that tell you what the submarine is going to do next. Moreover, the Mk 9 goes off in accordance with its depth setting, whether or not the target is near. So far as efficiency as an A/S weapon is concerned, that makes the Mk 9 wasteful, though still effective if you launch a number of depth charges, in a pattern that is reasonably certain to do in any submarine within the pattern. The rub is that exploding depth charges, whether they're killing a target or not, play havoc with the sonar gear. A depth charge that doesn't go off unless it gets close enough to damage a target, makes it simpler for sonar to stay on target.

The Mk 14 depth charge won't pursue the target like a homing torpedo or guided missile, but it is a pretty good answer to the disadvantages of the purely hydrostatic depth charge. Not that the Mk 14 isn't hydrostatically operated—it ARMS by hydrostatic pressure—but, once armed, it is DETONATED by an INFLUENCE-TYPE mechanism which functions to initiate the explosive train as the charge approaches the target.

The A–4 mechanism, which is responsible for this remarkable performance, is a complex and delicate electrically operated device. The details of its functioning and maintenance are beyond the scope of this course. Maintenance is more likely to be performed by Minemen than by Gunner's Mates. If you are assigned to perform detailed maintenance, adjustment, and repair of the A–4 and its associated gear, you will have to study the proper OP listed in OP 0. But in this chapter we can take up those shipboard operations (like stowage, handling, assembling, launching, and the like) that you are likely to be responsible for doing or supervising.

The Mk 14, by the way, is not the first influence-type depth charge ever issued to the Fleet. Its predecessor was the Mk 8, a depth charge with cylindrical aluminum case similar in appearance to the Mk 6 "ashcan." You may encounter the Mk 8 issued for training; it is not used for other purposes.

GENERAL DESCRIPTION AND FUNCTIONING OF MK 14 DEPTH CHARGE

The assembled depth charge Mk 14 Mod 0 (fig. 7–1) is made up of the following parts:

1. Depth charge case Mk 9 Mod 3 or Mod 4. These are very similar. As you know, the main difference between them is that the Mod 4 case has a stronger nose ring than the Mod 3. Figure 7–1, *A*, shows the Mod 4 case.
2. A–4 Mod 0 depth charge firing mechanism, an influence-type firing mechanism which is equipped with an anti-

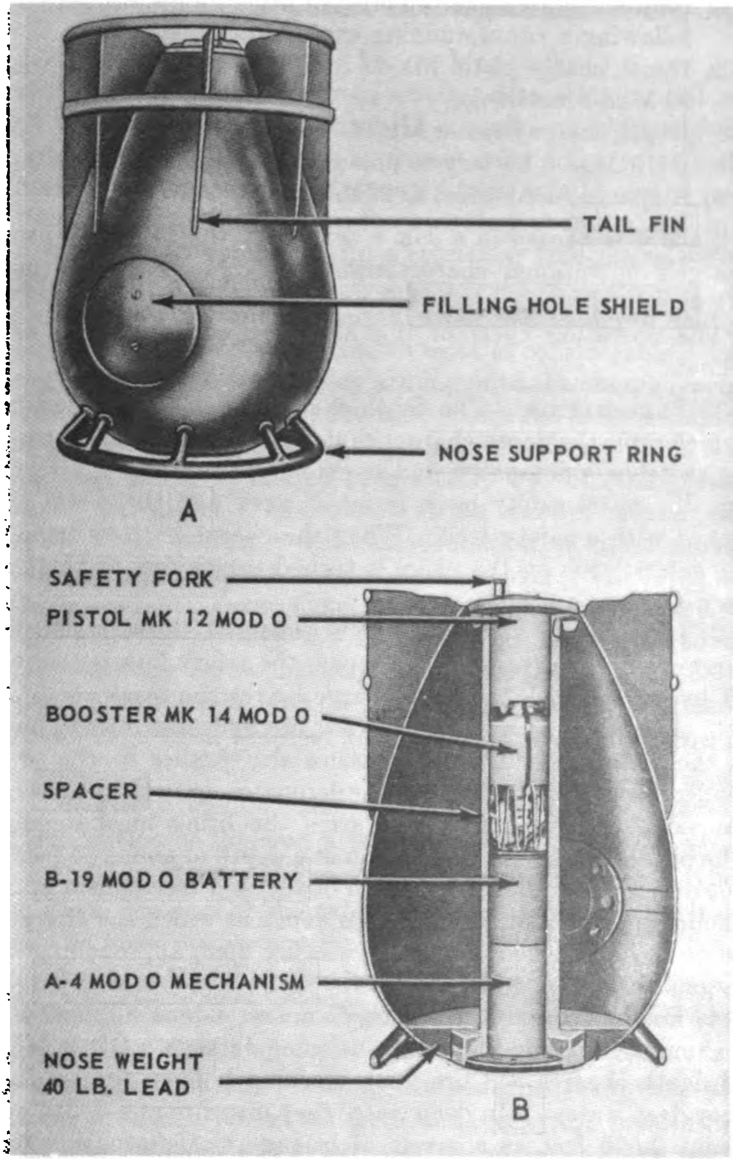


Figure 7–1.—Depth charge Mk 14 Mod 0. A. Exterior. B. Cross section.

countermining switch to prevent firing for a short period following a countermining explosion.

3. Depth charge pistol Mk 12 Mod 0 (with detonator Mk 35 Mod 1 installed).
4. Depth charge booster Mk 14 Mod 0.
5. B–19 Mod 0 battery to power the A–4 mechanism.
6. A spacer (used when available).

Since it is housed in a Mk 9 type case, the Mk 14 depth charge's operational characteristics resemble those of the Mk 9.

The operating cycle of the Mk 14 depth charge is as follows:

1. PREPARATION. The depth charge pistol Mk 12 Mod 0 (which arms the depth charge) contains two hydrostatic arming switches, a detonator, and an extender assembly. Before use, the pistol safety latch is set at SAFE and the pistol is locked with a safety fork. When the charge is to be used, the safety latch on the pistol is turned to SERVICE or to the deep-arming position.

2. LAUNCHING. If the charge is projected, the safety fork is removed by lanyard. If dropped, the safety fork is swept off by a wiping plate as the charge leaves the track.

3. ARMING. As the charge sinks, the hydrostatic switches in the pistol close. Water pressure also pushes in the extender assembly, which moves the detonator up to the booster, connects its firing leads, and arms the firing mechanism. The pistol completes its operation at a depth of about 35 feet, but other delays in the operation of the A–4 mechanism and the detonator make the minimum depth at which the charge becomes fully armed (so that it will fire upon approaching a target) about 65 feet.

4. DETONATION. If the charge is actuated by a submarine, it should cause either lethal or surfacing damage. Often Mk 14 depth charges will fire upon reaching bottom (except in very deep water). In deep water they may fire at a depth of about 2,500 feet as a result of leakage or deformation of the case by water pressure.

PISTOL AND DETONATOR FOR MK 14 DEPTH CHARGE

The depth charge pistol Mk 12 Mod 0 (figs. 7–2 and 7–3) is a hydrostatically operated arming device in the tail end of the Mk 14 depth charge. It contains an electric delay detonator Mk 35 Mod 1, a hydrostatically actuated extender mechanism to move the detonator from safe to armed position, and two hydrostatically operated switches, all in a brass case. A cable leads to a connector that mates with a plug on the battery cable.

Under certain circumstances, when Mk 14 depth charges are used to attack targets known to be at considerable depth, the pistol can be set to delay arming until the charge reaches a depth of approximately 200 feet. Since the A–4 mechanism is quite sensitive, this feature keeps the charge from accidentally being detonated prematurely by something other than the target. The DEEP-ARMING SAFETY LATCH (fig. 7–2), which performs this delay function, is fitted around the edge of the inlet hole on the pistol cover. The latch has three positions: SAFE, DEEP-ARMING, or SERVICE. The SAFE and SERVICE settings are embossed on the pistol cover. The securing screw between these two locates the deep-arming setting. A boss on the latch serves as index mark. At night, a fixed pin near the handle of the latch serves as a guide.

The safety latch is a thick metal ring with four projecting ears. Below is soldered a thin copper disc with four wider ears. The extender rod protrudes through the latch. When at SAFE, the ears of the extender rod are locked by the latch ring to keep the pistol from arming. When the latch is set for deep-arming, the extender rod is locked only by the ears of the thin copper disc; not by the heavier ears of the latch ring. At a depth of about 200 feet, hydrostatic pressure pushes the ears in, releasing the rod and permitting the pistol to arm. When the latch is at SERVICE, it does not lock the extender rod at all, and the pistol can arm at 35 feet.

Each pistol comes equipped with two safety forks: a plain shipping fork on the pistol, and a knobbed fork in a bag tied to the pistol. Either fits into a groove on the extender rod and locks it to keep the pistol from arming. The safety latch setting may be changed without removing the safety fork. The shipping fork is pulled off with a lanyard before the charge is projected.

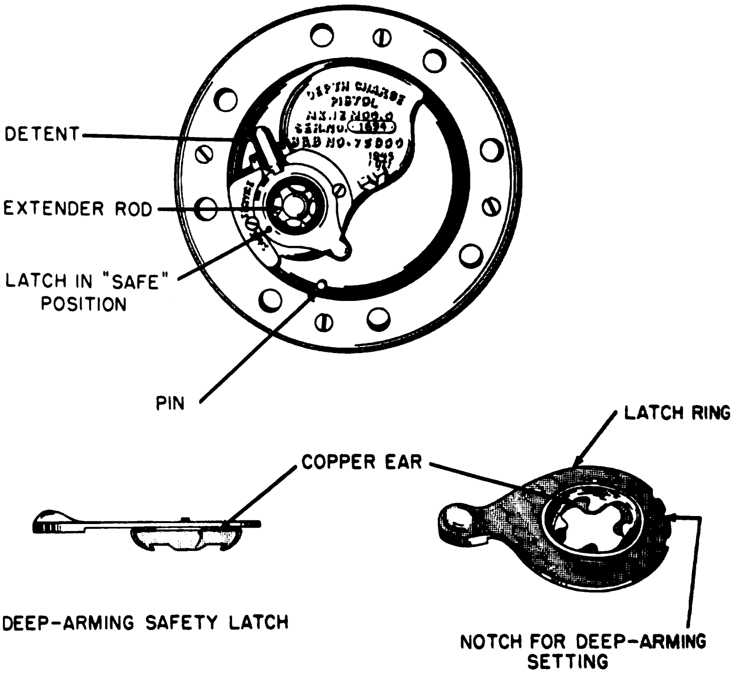


Figure 7-2.—Depth charge Mk 14: Face of pistol Mk 12 Mod 0, showing deep-arming safety latch.

The knobbed fork is substituted after a charge is placed in a release track; it is wiped off when the charge is released.

The electric delay detonator Mk 35 Mod 1 used in the depth charge pistol Mk 12 Mod 0 has a base charge of PETN and an internal time delay of 0.5 second.

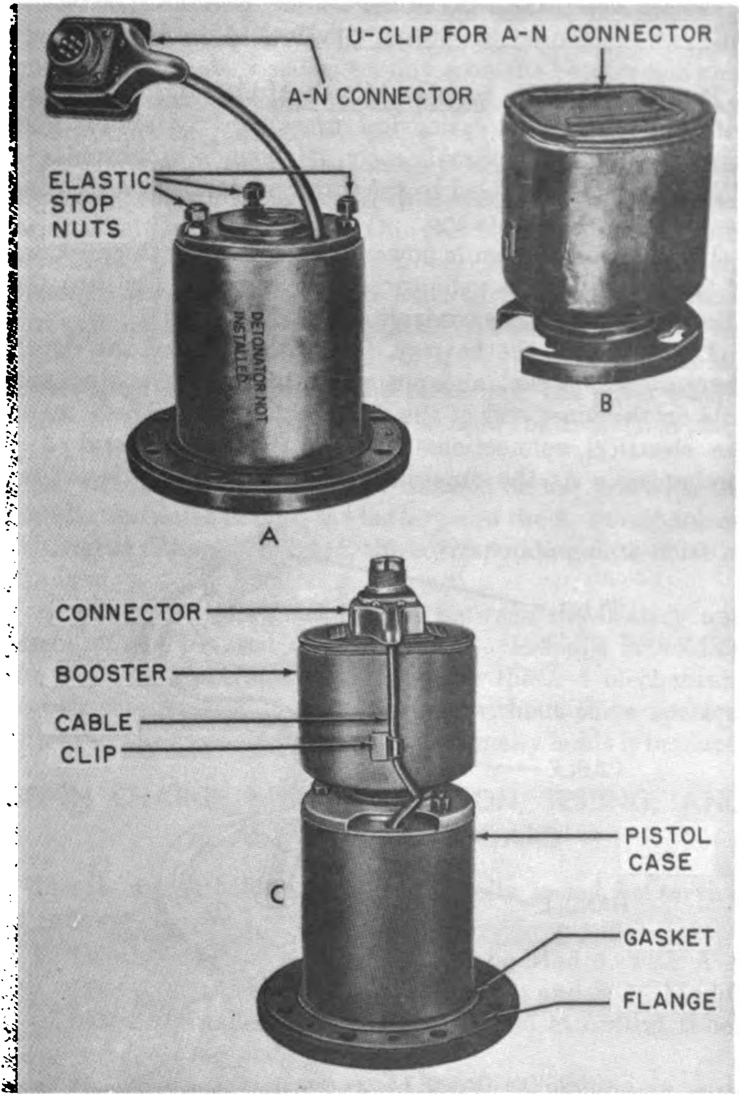


Figure 7–3.—Depth charge Mk 14. A. Depth charge pistol Mk 12 Mod 0. B. Depth charge booster Mk 14 Mod 0. C. Pistol Mk 12 Mod 0 assembled to booster Mk 14 Mod 0.

DEPTH CHARGE MK 14 BOOSTER, BATTERY, AND SPACER

The depth charge booster Mk 14 Mod 0 (fig. 7–3) used with the pistol is a cylindrical brass can containing four tetryl pellets and approximately 1¼ pounds of granulated TNT. When assembled to the pistol, a standard A–N connector is secured to its top.

The A–4 mechanism is powered by a B–19 battery—a set of battery cells in a cylindrical steel can that fits into the Mk 14 depth charge's control tube. (Fig. 7–4.)

At the end of the battery, facing the nose of the depth charge, are a socket and pin which mate with a plug and hole on the inner end of the A–4 mechanism. These make the electrical connections between the battery and A–4 mechanism. At the opposite end of the battery is a pre-

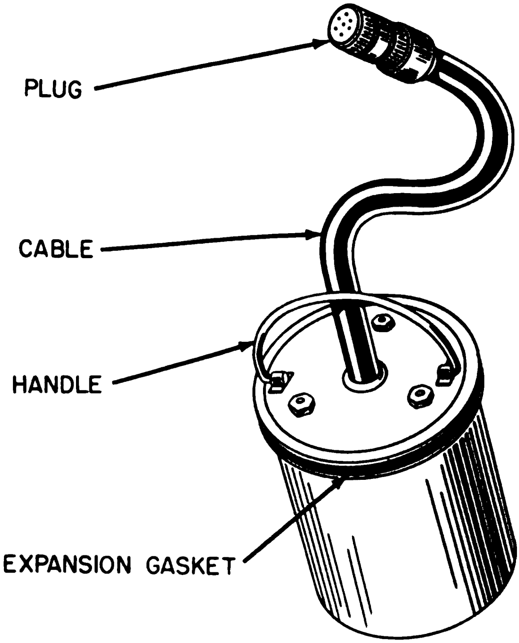


Figure 7–4.—Depth charge Mk 14: B–19 battery.

coiled 15-inch cable which ends in a plug. When the depth charge is assembled for ready stowage or launching, this plug mates with the A–N socket mounted on the booster and connected by another cable to the pistol. The cables contain switch and firing leads.

At the cable end of the battery is an expansion gasket assembly (shown in fig. 7–4), consisting of two plates with two gaskets between them. One gasket is around the center hole in the plates; the other is around the outer edges of the plates. Three threaded studs fixed to the one plate extend through holes in the other plate. When the nuts on the studs are tightened, the gaskets are squeezed so that the inner one tightens around the cable and the outer gasket takes up against the central tube to hold the battery in place and keep moisture out.

All depth charges Mk 14 are marked on the fins with the installation dates of both the battery and the A–4 mechanism. Whenever either is replaced, the corresponding date must be changed.

A wire spacer designed for use between the battery and pistol should be used when available. It helps in holding the battery in position with respect to the A–4 mechanism. Depth charges Mk 14 may be used without these spacers, however; the gasket on the battery normally holds it in place.

DEPTH CHARGE MK 14: INSPECTION, TESTING, AND STOWAGE ON SHIPBOARD

Depth charge Mk 14 Mod 0 is usually issued for service as follows:

1. Depth charge case Mk 9 Mod 3 or Mod 4, with A–4 Mod 0 depth charge firing mechanism and B–19 Mod 0 battery installed, spacer (if available) in central tube, and blanking plate on tail.
2. Depth charge pistol Mk 12 Mod 0 in metal can with detonator Mk 35 Mod 1 installed, shipping fork in place, knobbed fork attached (in a small bag) and deep-arming safety latch set on SAFE.

3. Depth charge booster Mk 14 Mod 0 in metal boxes of 12.

The preferred sequence of operations for handling depth charge Mk 14 is—

1. Inspecting.
2. Testing of battery and A–4 mechanism with shipboard test set.
3. Placing topside charges in release tracks, projectors, or stowage racks, and assembling them ready for use.
4. Stowing the excess over the topside requirements.

Inspection of Mk 14 Depth Charges

Let us begin with inspection.

All charges should be inspected and tested immediately after being brought aboard.

First, see that the A–4 mechanism is seated properly. Examine its black outer gasket for cracks. This gasket must be in good order, with the A–4 mechanism drawn up tightly and uniformly against it. If the mechanism is not seated properly, set aside the charge to be further tightened by authorized personnel.

Look for damaged A–4 faceplates and for damaged fins or rings on the cases. Reject any charges that do not pass this inspection.

Testing Mk 14 Depth Charges

Next comes the testing of A–4 mechanisms and batteries, done with the depth charge test set Mk 45 Mod 0 BEFORE the pistols are assembled in the charges. This test set (fig. 7–5) looks much like a flashlight. It has a voltmeter at one end, a cable at the other, an indicator lamp, two switch buttons on one side, and a rotary switch at the cable end of the test-set housing for turning the set on and off.

The cable has a 7-pin connector which fits the connector on the end of the battery cable. The voltmeter has two scales—one calibrated 0–150 volts, and the other with a small green sector at the left side and a long red sector at the right side. The buttons, which are interlocked so only

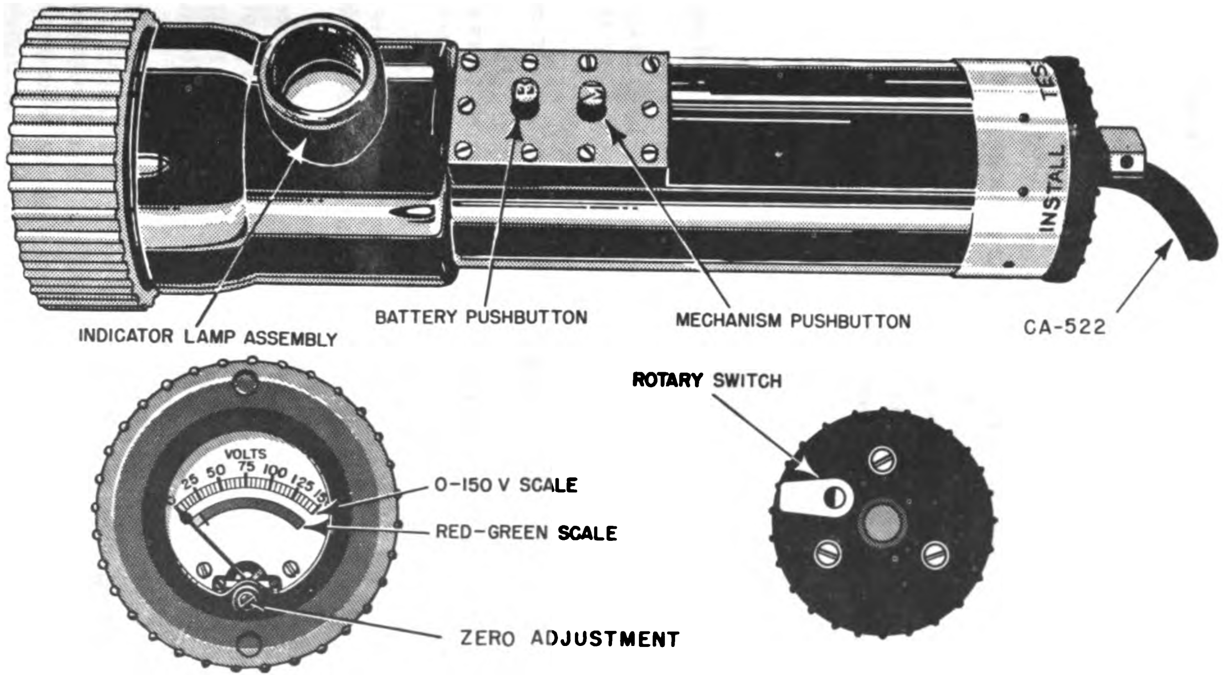


Figure 7-5.—Depth charge test set Mk 45 Mod 0.

one can be depressed at a time, are marked *B* (battery) and *M* (mechanism). The rotary switch on the rear plastic cover can be set at INSTALL or TEST.

This test set is used for three tests on Mk 14 depth charges:

1. Test for voltage in the A–4 mechanism firing circuit. To pass OK, the voltage must be BELOW that necessary to fire. Otherwise the mechanism is unsafe because it will cause premature functioning.
2. Test of battery. To pass OK, the battery must produce at least a certain minimum voltage in order to ensure that it will properly energize the mechanism.
3. Test of A–4 mechanism operation. To pass OK, the mechanism should produce a firing impulse when (and only when) its sensitive face is stimulated.

Here is how you perform the first test:

1. Remove the pistol or blanking plate from the tail end of the charge.
2. Turn the rotary switch on the test set to INSTALL. Plug the test set connector into the socket on the battery cable.
3. Hold the test set vertically so that you can easily see the meter.
4. Watch the meter and turn the rotary switch to TEST. The needle should stay in the green part of the scale. If it flicks out of the green, reject the charge—even if the needle comes to rest in the green. Be careful here: jarring or twisting the test set can also cause needle deflection.
5. If the assembly is not acceptable, turn the rotary switch to INSTALL, disconnect the test set, and set the depth charge aside. If it is acceptable, leave the rotary switch at TEST and go on with the tests described below.

Now for the second test:

1. Hold the test set vertical as before.
2. Press button *B* for about 5 seconds. Read the voltage on the 0–150 scale and compare it with the table below. The meter should show a voltage at least as high as

that given in the table for the temperature of the battery at the time of the test. Estimate the temperature of the battery on the basis of the surrounding atmospheric temperature for the previous 3 to 6 hours. (In emergency, if other charges are not available, the voltage for rejection may be reduced by as much as 10 volts below the value shown in the table. But the actuation range of the depth charge will be reduced, especially at low temperature.)

3. If the voltage is lower than specified, even after the test is repeated several times, reject the depth charge.

NOTE. This test checks only one part of the multisection B–19 battery. It may test OK, yet other sections may fail to energize the A–4 mechanism properly. Especially if the battery is over 6 months old, failure of the A–4 mechanism on the next test is probably due to battery failure.

BATTERY TEMPERATURE AND VOLTAGE TABLE

Temperature (° F) of battery	Minimum voltage
0 to 10	106
10 to 40	110
40 to 60	119
60 to 80	123
80 to 100	127

The last test is for the A–4 firing mechanism. Here is the procedure:

1. Place the depth charge so that you can reach the faceplate of the A–4 mechanism with one hand.

2. Hold the indicator light housing of the test set to the eye so that all outside light is excluded. (Fig. 7–6.)

3. Press button *M*. After an interval of 5 or 6 seconds, press firmly against the raised center of the A–4 mechanism faceplate with one hand and scrub it hard. Or you can vigorously pat the center of the faceplate with the fingers

or hand. If the battery and mechanism are both in working order, the lamp will flash within 5 seconds. ONE flash is sufficient to determine the operating condition of the mechanism and battery. But be alert to detect that flash. ANY flash, whether bright or dim, is enough to indicate that the assembly is OK. If the lamp does not flash in 5 seconds, release button *M*, wait 10 seconds, and try again. Try the test at least six times before rejecting.

> NOTE. While testing, never press button *M* longer than 15 seconds at one time. If there is a flash at any time except when button *M* is depressed and the mechanism is actuated, or if there is a continuous glow at any time, the mechanism or battery is faulty and the charge should be rejected.

4. After you have completed the test, but before the test set is disconnected, be sure the meter pointer is in the green part of the scale when no buttons are depressed. If the meter shows a red-scale reading, the assembly may fire a detonator prematurely, and the pistol must NOT be installed. Reject the charge.

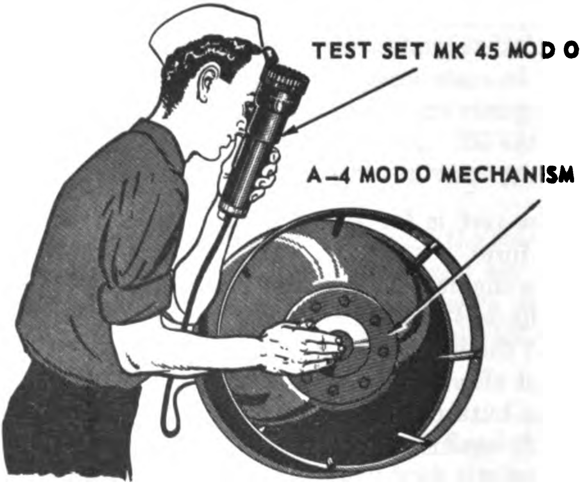


Figure 7–6.—Depth charge Mk 14: Testing the firing mechanism.

5. Turn the TEST-INSTALL switch to INSTALL.

6. Disconnect the test set, and go on to the next charge.

If you find that your testing yields a steady series of rejects, the Mk 45 test set may itself be faulty. Try another test set. Only authorized personnel should ever make any attempt to disassemble the test set to make repairs of any kind.

The shipboard test checks only battery voltage and firing mechanism operation. Firing mechanisms, pistols, and batteries are normally turned in for complete testing every 6 months (or sooner, if charges fail the shipboard test). This complete testing is done at shore stations or on destroyer tenders with the proper test equipment. To keep the transfer of charges to a minimum, the depth charges may be disassembled by qualified personnel and components to be tested taken to the tender or shore station.

Remember that the Mk 45 test set imposes a heavy drain on the B–19 battery. So make the test snappy; don't keep the test going on any one depth charge any longer than absolutely necessary to determine whether the charge is OK or not.

Assembling Mk 14 Depth Charges on Shipboard

Boosters should be assembled to pistols only when the assemblies are to be mounted in depth charges stowed topside in projectors, release tracks, or stowage racks. Here is the procedure (check with fig. 7–3):

1. Inspect the booster for damage.

2. Loosen (but do not remove) the elastic stop nuts on the studs on the booster end of the pistol.

3. Place the booster can on the pistol so that the stop nuts pass through the slots in the ring on the booster. Turn the booster can clockwise until the studs completely engage the bayonet slots. Tighten the elastic stop nuts.

4. Insert the connector socket at the end of the pistol cable in the U-shaped clip on the end of the booster can, and secure the cable under the clip on the flat side of the booster can.

To install the pistol assembly:

1. Remove the blanking plate and gasket from the depth charge tail flange. (Don't use the blanking plate gasket with the pistol.)

2. Inspect the central tube of the depth charge case to see that it is clean and dry. If a spacer is available, shove it into the tube until it meets the battery.

3. Be sure the pistol safety lock is at SAFE, that a safety fork is in place, and that a gasket is installed in the retaining groove on the inner face of the pistol flange.

4. Remove the cap from the male connector on the end of the pistol. Grasp the connector plug on the depth charge battery cable and gently pull the cable to the end of the central tube. Don't try to straighten a precoiled cable. Remove the cap from the plug. See that the grease in the plug is free of dirt. Do NOT remove the grease; instead, replenish it if necessary.

5. Test the battery and A–4 mechanism with the Mk 45 test set. If the A–4 mechanism and battery do not test OK, don't install the pistol, but set the depth charge aside. If they do test OK, plug the battery cable into the pistol cable connector. The plug will go in only one way; don't try to force the parts together in any other. Screw the clamp ring tight.

6. Insert the pistol in the central tube until it seats against the depth charge tail flange. If necessary, twist the pistol slightly clockwise to fit into the central tube and to align the holes in the pistol flange with those in the case.

7. Fasten the pistol in place with the eight cap screws provided. Tighten diametrically opposite screws evenly with a speed wrench until the gasket is compressed and the pistol flange meets the depth charge tail flange with a metal-to-metal contact.

8. If the charge is to be dropped from a track, replace the shipping safety fork on the pistol with a knobbed safety fork. The knob on the fork must be near the center of the

pistol head plate, or the wiping plate on the release track may fail to remove the fork when the charge is dropped.

9. If the charge is to be projected, attach a lanyard about 1 foot long to the shipping safety fork so that the fork can be pulled off before the depth charge is projected. SAFETY NOTE: Do NOT tie the free end of the lanyard to the projector, or to anything else; YOU are supposed to pull the safety fork off.

10. All pistols should be kept set at SAFE until the last practicable moment before the charges are launched.

Handling and Stowage of Mk 14 Charges

In most respects, stowage requirements of Mk 14 charges are similar to those for Mk 9, except that Mk 14's, when assembled, are more sensitive and should be handled with appropriate care. Uncrated charges should not be carried in cargo nets; the A–4 mechanism faceplates or the depth charge cases may be damaged. When placing a depth charge in a release track, place it so that the tail end of the charge is at the more accessible side (usually inboard) to facilitate pistol installation. Uncrated charges must be battened down during stowage or shipment. Don't stack uncrated charges on top of each other like barrels. It is best to stow them upright in one or two tiers separated by a platform, or horizontally in racks. Stow charges so that those with the oldest batteries will be used first.

Handle components with due caution. Pistols are live ammunition; stow and handle them accordingly. Keep empty pistol containers; they are handy for stowing pistols temporarily removed from depth charges on deck.

Stow boosters separately from pistols, preferably in the depth charge magazine. Special ½-inch steel blanking plates with three tapped holes may be provided for stowage of boosters in depth charge cases. Boosters may be secured to these blanking plates by three machine screws inserted through the slots in the booster bayonet ring to prevent distortion of the ring.

MK 14 DEPTH CHARGE MAINTENANCE POINTERS

Here are some general maintenance pointers for the Mk 14 depth charge that you should incorporate into shipboard routine.

Maintenance of A–4 Mechanism and Battery

1. Never allow the faceplate of an A–4 mechanism to be scratched or dented; never paint, slush, or otherwise coat it. If the faceplate is greasy, dirty, or fouled, clean it with trichlorethylene or some other authorized cleaning solvent. Don't use soap or carbon tetrachloride. Newly issued charges may have faceplates coverd with a protective coating of tectyl. This coating must be removed also.
2. Keep the entire depth charge, and especially the A–4 faceplate, as free of ice as possible. Ice on an A–4 mechanism may cause it to fire upon arming. Use a steam jet to remove ice.
3. Be sure the large black gasket around the A–4 mechanism is present, and shows no sign of cracking or deterioration. Lack of the gasket causes the charge to explode near its arming depth.
4. Always keep both the A–4 mechanism and battery as dry as possible. Don't leave the pistol end of the central tube open; cover it with a blanking plate whenever the pistol is removed.
5. A–4 mechanisms must be replaced by freshly tested mechanisms every 6 months; stencil the date of installation on the depth charge case. Only authorized personnel may remove or replace A–4 mechanisms. Normally, if an A–4 does not pass the shipboard test, the entire charge should be set aside, to be turned in at the earliest possible time.
6. Battery replacements should be requested at the end of the useful life predicted for the battery, or as soon as possible after failure to pass the shipboard test. Only authorized personnel may remove or replace batteries.
7. A waterproofing grease, 14G10 (Ord), is used on the cable plugs to prevent corrosion. It does NOT prevent the

plug from making a good electrical connection. Replenish the grease on connector plugs when necessary.

8. It may happen that there will be enough material failures in Mk 14 depth charge components to deplete your stock of effective charges, and that this will happen at a time when replacement A–4 mechanisms or B–19 batteries are not available. Under these circumstances, your gunnery officer or ASW officer may order you to substitute, in the Mk 14 depth charges that have been put out of action, Mk 6 Mod 2 depth charge pistols and associated components to convert the Mk 14 depth charges to Mk 9 Mod 4 charges. In this way it will be possible to maintain a full load of effective depth charges when you need them.

Depth Charge Testing Schedule

Test all topside charges every 3 weeks in the Tropics and every 5 weeks in cooler zones. Replace charges that fail. Test all charges when transferred from magazines to deck stowage.

Test magazine-stowed charges every 4 weeks in the Tropics and every 8 weeks in cooler zones. Charges to be tested may be hoisted topside if testing in the magazine is not feasible.

To keep the amount of testing within manageable limits, use a SAMPLING technique, as follows:

1. Arrange charges in magazines so that those aboard longest are most accessible for replacement use. Stow other groups of charges so that a sample from each group is accessible for testing.

2. Test about 15 percent of each group or batch (by date of mechanism installation) with the test set Mk 45 Mod 0 for battery condition. Test at least two charges of each batch, and a total of at least 10 charges. When any failures are detected in the sample of a particular batch, continue testing that batch to determine whether a large percentage of the batch has failed, or whether there are only a few isolated failures.

3. If more than 30 percent of any batch shows poor battery condition, reject the entire batch and set it aside. Otherwise, set aside only the individual charges.

4. Defective units should be reported, using the report forms illustrated in OP 1577.

Maintenance of Pistol and Booster

1. Pistols should be turned in every 6 months and replaced with recently tested units. Latest test dates are stamped on the pistol flanges.

2. Replace the square gasket on the pistol whenever it becomes set, cracked, or distorted. If possible, replace it when the pistol is removed.

3. Remove the pistol and booster assemblies from the depth charges upon entering port, if operationally practicable. While in port, the pistols and boosters are to be stowed separately.

4. Never carry pistols by their cables.

5. Inspect boosters for damage (especially the clip welds). A booster may be turned in if it is slightly damaged, but if the seam is open so that the TNT is exposed, dispose of the booster over the side into deep water while under way.

Premature Arming of Pistols

Any pistol which becomes prematurely armed must be considered dangerous until disarmed. You can detect premature arming by noting the position of the end of the extender rod, which projects through the top of the pistol. If the rod projects far enough for a safety fork to be slipped on it, the pistol is safe. But if the end of the rod does not project far enough to permit safety fork installation, consider the pistol to be armed.

Here is what to do:

1. Reach into the opening in the top of the pistol with a pair of small-nose pliers, and grasp the extender rod.

2. Pull out the rod gently until a safety fork can be placed on it.

3. Install a safety fork and set the safety lock at SAFE.

4. If there is no evidence of damage to the pistol, it may be considered usable. But if there is evidence of damage to the pistol, remove the booster and return the pistol to a shore base for inspection.

5. If the pistol cannot be disarmed, cast it over the side into deep water while under way.

Other Maintenance Pointers

1. If any ring or fin or supporting bracket is cracked or loose, so that it can vibrate freely when the charge is sinking, set the charge aside. Underwater vibration of cracked rings, broken welds, and so on, may cause faulty operation. Bent fins may cause erratic underwater trajectory. If the bolts holding the filling-hole shield cannot be secured tightly, remove the shield and use the charge only if necessary.

2. Inoperative depth charge test sets Mk 45 Mod 0 should be turned in to issuing activities.

3. Air pressure in the central tube varies with temperature, and such changes affect the operation of the pistol extender and arming switches. Therefore, whenever a ship experiences large temperature changes (50° F or so), momentarily loosen cap screws on all assembled charges to allow air pressure to equalize, then retighten.

SUMMARY AND REFERENCES

In this chapter you have studied the influence-type depth charge, the Mk 14, now being issued to the Fleet. You have taken up its general construction and operation, how it is prepared for use, how it is tested, and how it is stowed and maintained aboard ship. But there is not enough in this chapter to make you an expert on the Mk 14. You will find some further information on shipboard handling in OP 1577. But to get detailed information on the principles of operation, adjustment, maintenance, and repair of the A–4 mechanism, the B–19 battery, the Mk 12 pistol, and the Mk

45 test set, you will have to consult OP 0 for the proper source of information.

However, this chapter does contain, by and large, the information you will require for shipboard use of the Mk 14, short of these classified details. It is worth your close study, especially because Mk 14 depth charges are the most important A/S weapons of their type now being issued to the Fleet.

QUIZ

In each of the following, select the BEST answer.

1. Which of the following functions in the Mk 14 depth charge is initiated hydrostatically?
   a. Depth setting
   b. Detonation
   c. Arming
   d. Tracking
2. Which of the following components of the Mk 14 depth charge is an INFLUENCE-TYPE device?
   a. B–19 battery
   b. Mk 12 Mod 0 booster
   c. Mk 14 Mod 0 pistol
   d. A–4 mechanism
3. Under normal circumstances, the Mk 14 depth charge becomes FULLY armed
   a. at a depth of about 200 feet
   b. at a depth of about 65 feet
   c. at a depth of about 35 feet
   d. upon approaching its target
4. Which of the following is NOT one of the possible settings for the deep-arming safety latch on the Mk 14 depth charge?
   a. Service
   b. Deep arming
   c. Delay
   d. Safe
5. When the safety fork is removed from the pistol on the Mk 14 depth charge, the
   a. A–4 mechanism is actuated
   b. A–4 mechanism is energized
   c. pistol is armed
   d. extender rod is released
6. Which of the following is NOT tested by use of the Mk 45 test set for Mk 14 depth charges?
   a. Mk 12 pistol functioning
   b. A–4 mechanism functioning
   c. Battery voltage
   d. A–4 mechanism firing circuit voltage

7. If, in the course of the A–4 mechanism test, the indicator light in the Mk 45 test set flashes ONCE, it means that
    - a. the Mk 12 pistol is unsafe to install
    - b. the A–4 mechanism may fire the detonator prematurely
    - c. the A–4 mechanism is OK
    - d. there is too much voltage in the firing circuit

8. Do NOT assemble boosters and pistols in Mk 14 charges that are to be stowed in
    - a. magazines
    - b. projectors
    - c. release tracks
    - d. topside stowage racks

9. When assembling the booster and pistol in the Mk 14 depth charge, you should plug the cable from the battery into the cable from the
    - a. Mk 45 test set
    - b. A–4 mechanism
    - c. booster
    - d. pistol

10. To protect the A–4 mechanism, its faceplate should be coated with
    - a. one coat of rust-resistant paint
    - b. slushing compound
    - c. 14G10 grease
    - d. none of the above

CHAPTER 8

ROCKETS, LAUNCHERS, AND PROJECTORS

INTRODUCTION

In this chapter we shall take up some of the newer weapons of the Fleet. Except for the depth charge projectors and launching tracks discussed at the end of the chapter, these weapons are all developments of World War II and thereafter. Though all these newer weapons are, like guns, powered by burning propellants that produce hot, expanding gases, the forces so developed are differently applied, and we shall therefore have to take up principles of operation before going into constructional detail. That is why there is a good deal of fairly elementary material for you to study. It is important for you to grasp these elements because of their importance in new weapons of these types that you will continue to encounter in your career as a Gunner's Mate.

Remember—YOU are expected to be the expert. To fulfill that expectation you must keep up to date on all the new developments in these weapons by studying new OP's, changes, OCL's, OML's, and ordnance information bulletins as they appear. As you have no doubt learned by now, if you study your Navy training courses to understand the basic principles, you have a head start when you study in ordnance publications the use, functioning, repair, and upkeep of the new marks and mods that keep the Fleet at a top pitch of effectiveness.

We shall begin this chapter by taking up first rockets and their launchers, then A/S projectors and their ammunition, and, finally, depth charge projectors and launching tracks. The depth charges themselves you studied in the two chapters preceding this.

ROCKETS

Before World War II, any military expert could have told you that although rockets were by no means new to naval warfare, they were limited to use in signaling. Today, the Navy still uses signal rockets, but rockets now have developed into a revolutionary means of propulsion for both weapons and aircraft.

Not all types of rocket weapons are taken up in this section. Some are still in experimental stages of development or are not the sole responsibility of Gunner's Mates. Some are highly classified and cannot be discussed in this training course. Nor are JATO and other aircraft propulsion rocket units taken up here; they are not the responsibility of Gunner's Mates. As for rockets launched from aircraft, space permits only passing mention of them in this course. The rockets discussed here are current types launched from shipboard against surface or underwater targets.

The rapid development of new types of rockets and guided missiles keeps the discussion of rockets, projectors, and launchers in this section from being the latest, up-to-the-minute information that you will require if you really need to be abreast of the subject. Stay up to date on OP's, OCL's, and similar sources to be sure you are well posted. All that this section presents is basic information on rocket operation, handling, stowage, and safety precautions, and on rocket launchers.

Identifying Rockets

A COMPLETE ROUND of rocket ammunition is one rocket (head plus motor) assembled with all components required for full operation, ready for service use. The official BuOrd nomenclature for complete rocket rounds is determined by combining descriptive terms as follows:

1. Caliber (defined as the nominal outside diameter of the rocket head).

2. The word "Rocket."
3. Mark and mod.
4. Parenthetical phrase specifying type of craft from which launched, such as "aircraft" or "surface," followed by the designation "practice" or "dummy," if applicable, or by designation of the head type (high capacity, common, general purpose, etc.), including "SS" for spin-stabilized rockets.

The following are examples of complete round nomenclature:

5.0-inch ROCKET MK 7 MOD 2 (SURFACE HIGH CAPACITY SS)
11.75-inch ROCKET MK 3 MOD 0 (AIRCRAFT COMMON)

The caliber of the rocket head determines the caliber of the complete round—thus, all rockets with 5-inch heads are 5-inch rockets, regardless of the sizes of other components. Mark numbers are assigned in series within calibers; thus, 5-inch rockets and 3.5-inch rockets have mark numbers in separate series.

All rockets of a given caliber and mark number have the following characteristics in common:

1. They are of the same dimensions and are interchangeable as far as fitting on launcher installations is concerned. This interchangeability applies also to matching the electrical connectors for firing.
2. They are essentially similar in exterior ballistics.
3. They are fitted with the same basic type of head (HC, GP, Smoke, etc.). Thus, a 5.0-inch HC rocket cannot have the same mark number as a 5.0-inch smoke rocket.

Within a given caliber and mark number, different mod numbers are usually assigned when rockets differ as follows:

1. Different types of fuzes are used (for example, nose only, base only, or nose and base).
2. Different fuze delays are used.
3. The dimensions, though similar enough to permit interchangeability on launchers, are different enough to require different stowage or handling gear.

4. Different fillers are used with the same basic type of head. For example, two 5.0-inch smoke rockets of the same mark number, one filled with chemical smoke, the other with WP, would have different mod numbers.

Solid-Fuel Rockets Used in the Navy

The solid-fuel rockets now in use as naval weapons include 3.5-, 4.5-, 5.0-, 7.2-, 11.75-, and 12.75-inch sizes; there are other (experimental) types now under development. Rockets fired from aircraft include 2.25-, 3.5-, 5.0-, and 11.75-inch types. Shipboard rockets now issued as standard ammunition include 4.5-, 5.0-, 7.2-, and 12.75-inch sizes. The 4.5-, 5.0-, and 7.2-inch rockets are fired from the decks of ships and craft, and are variously utilized in close support of landing operations. The 7.2-inch rockets are used also as antisubmarine (A/S) weapons; the 12.75-inch rockets are used exclusively for antisubmarine warfare.

This chapter will take up the 4.5-, 5.0-, 7.2-, and 12.75-inch rockets and their launchers.

Rocket Review

You are already familiar with the principles of rocket propulsion in general. The main idea is that the rocket propellant, as it burns, produces hot gas that is ejected under pressure from a nozzle or set of nozzles at the rocket's after end. As the gases push outward to the rear, they exert an equal push forward on the rocket, and that is what moves the rocket forward. You remember that the rocket gases do NOT propel the rocket by pushing at the air; the fact is that rockets work even better in a vacuum than in the atmosphere. You should be familiar with all this from earlier courses in this series.

Modern rockets are propelled by either liquid or solid fuels. So far, none of the rockets with which you will deal are liquid-fueled. Liquid-fueled rockets will not be discussed in this course.

Rockets, unlike gun projectiles, carry their own propelling charges as they take off. Unlike guns, they develop no tremendous chamber pressures, and they exert no recoil forces on their launchers. These advantages make it possible to launch them from light tubes or rails mounted on the relatively frail structures of small watercraft, aircraft, and trucks; in effect, a rocket-equipped fighter plane fires the equivalent of 5-inch and larger projectiles. The launching devices merely provide electrical contacts for igniting the rocket propellant, and guide the rocket for the first part of its trajectory.

Rockets have certain disadvantages, however; they require more propellant than do gun projectiles to attain equal velocity—other things being equal—and rocket fire is far less accurate and of shorter range than the fire of guns of equal caliber.

ROCKET MOTORS

Now that we have reviewed what you already have studied about rockets, let us consider rocket motors in greater detail, beginning with the nozzle end. (Rocket heads will be taken up later in this chapter, along with specific types of rockets.)

The function of the nozzle is to permit the hot gas produced by the burning ballistite propellant to flow out of the rocket motor, pushing the rocket along as it goes.

The shape of the nozzle determines the characteristics of gas flow, and hence has much to do with how efficiently the gas flow propels the rocket. Gas flow must be smooth (nonturbulent). For a smooth, controlled trajectory, it must produce thrust along the long axis of the rocket. And the nozzle must be designed to develop every possible bit of thrust from the flow.

By tapering the rear of the chamber so that it narrows smoothly toward the nozzle aperture, a smooth, nonturbulent flow of escaping gas is created. This tapered section forms the forward half of the nozzle. The tapered extension, forming the after end of the nozzle, which leads outward from the nozzle aperture, forces the escaping gas, as it expands, to furnish additional (about 33 percent) forward thrust. (Fig. 8–1.)

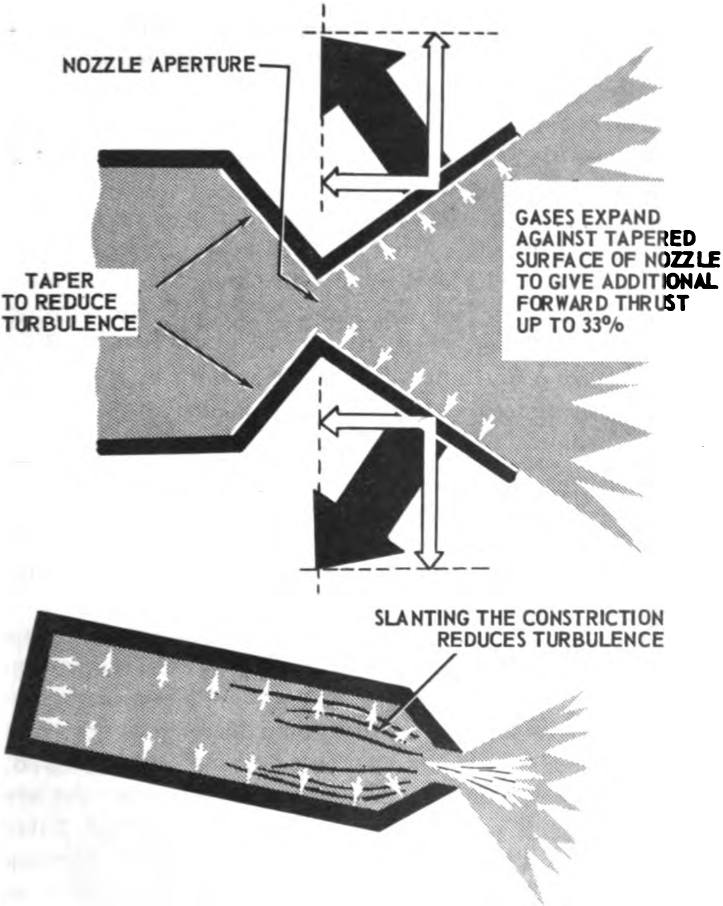

NOZZLE APERTURE
TAPER TO REDUCE TURBULENCE
GASES EXPAND AGAINST TAPERED SURFACE OF NOZZLE TO GIVE ADDITIONAL FORWARD THRUST UP TO 33%
SLANTING THE CONSTRICTION REDUCES TURBULENCE

Figure 8–1.—Rocket motor nozzle design.

Many rockets have a number of nozzles, rather than just one. The same principles apply there.

The rocket MOTOR TUBE contains the propellent charge and igniter. It is a combustion chamber in which the propellant is burned to provide the motive power (hot gases) for the rocket. It generally threads to the rocket head or an adapter in the base of the head, and is usually shipped separate from the head. The diameter of the motor is less than that of the head in some rockets; in others its diameter is about the same as the head's.

The IGNITER contains black powder loosely packed, and an electric SQUIB with a low resistance bridge wire running through a match composition.

All present types of rocket motors are initiated electrically. As figure 8–2 shows, the firing impulses may be transmitted either by a pigtail lead from the rocket plugged into a source of firing current, or by contact surfaces on the shroud surrounding the rocket's tail.

The ballistite propellant is formed into grains by a solventless extrusion process. Most Navy rockets use either a solid cruciform grain or a cylindrical grain with an axial hole and radial perforations. The latter, often used in Navy ground or shipboard mounted rockets, is characterized by three ridges spaced 120° apart and running longitudinally along the grain. (Fig. 8–3, *A*.) The cruciform grain (fig. 8–3, *B*), usually found in Navy aircraft rockets, in section is a symmetrical cross. If all of the exterior surface of this grain were permitted to burn, there would be a gradual decrease of area, and the burning rate would be REGRESSIVE—that is, the rate of gas production would decrease as the grain continued to burn. Since a UNIFORM burning rate is desired, a number of slower burning plastic strips or INHIBITORS are bonded to certain parts of the area exposed on the outer curved ends of the arms. These slow the initial burning rate, and gas production rate is approximately uniform as long as the grain burns.

Hollow cylindrical grains have inherently uniform burning rates and usually require no inhibitors.

Grain sizes vary according to the motor in which they are to be used. Most use only a single grain, but some may use up to four.

The GRID is a metal piece near the nozzle which supports the propellent grain so that sufficient clearance is allowed between the grain and the nozzle to permit a free flow of gas through the nozzle. (Fig. 8–4.) Without the grid, the grain will move aft, blocking the nozzle and causing excessive pressures to build up in the motor.

Tail FINS provide stability in flight, prevent tumbling, and ensure head-on impact. During burning, the action of the air against the fins tends to resist side forces of the nozzle and to improve the accuracy of fire. When there is a tail

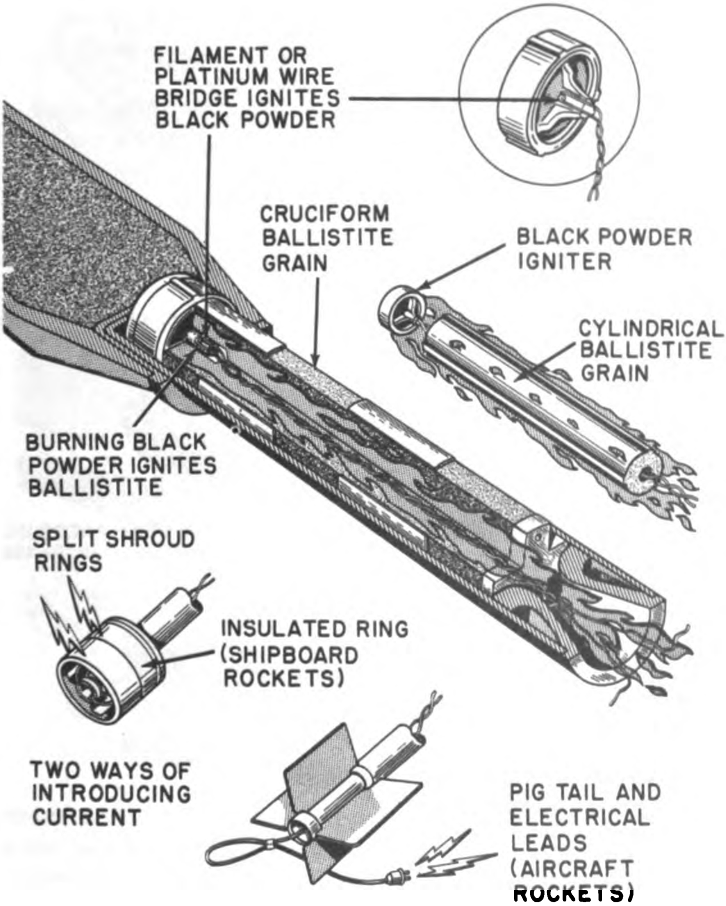

FILAMENT OR PLATINUM WIRE BRIDGE IGNITES BLACK POWDER
CRUCIFORM BALLISTITE GRAIN
BLACK POWDER IGNITER
CYLINDRICAL BALLISTITE GRAIN
BURNING BLACK POWDER IGNITES BALLISTITE
SPLIT SHROUD RINGS
INSULATED RING (SHIPBOARD ROCKETS)
TWO WAYS OF INTRODUCING CURRENT
PIG TAIL AND ELECTRICAL LEADS (AIRCRAFT ROCKETS)

Figure 8–2.—Rocket motor ignition.

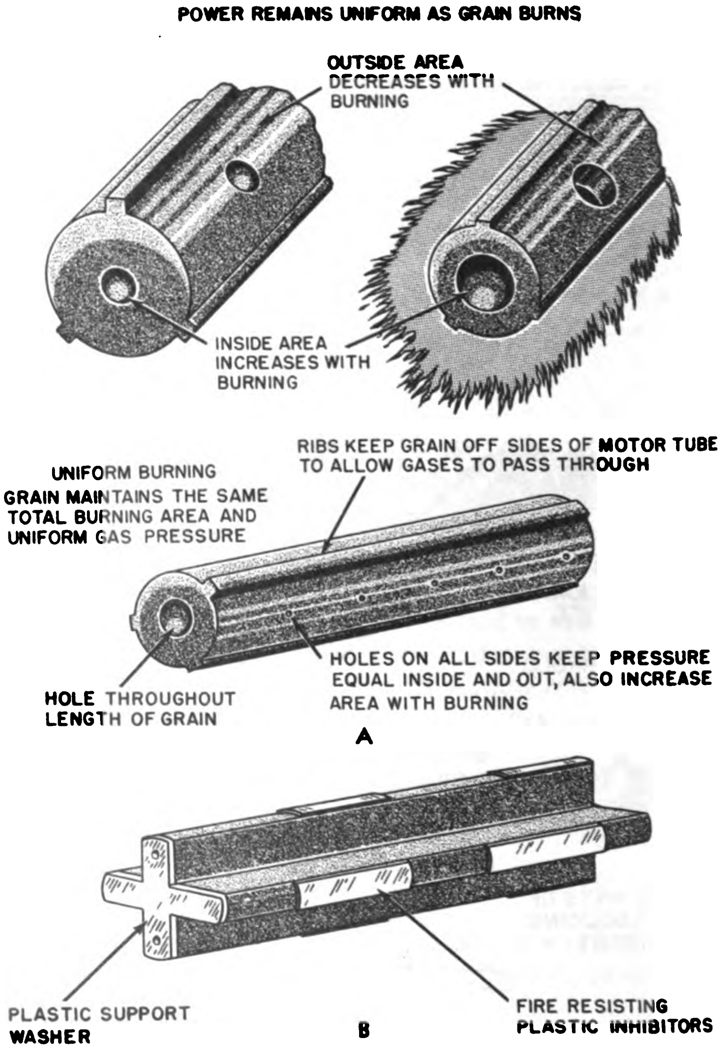

POWER REMAINS UNIFORM AS GRAIN BURNS
OUTSIDE AREA DECREASES WITH BURNING
INSIDE AREA INCREASES WITH BURNING
RIBS KEEP GRAIN OFF SIDES OF MOTOR TUBE TO ALLOW GASES TO PASS THROUGH
UNIFORM BURNING
GRAIN MAINTAINS THE SAME TOTAL BURNING AREA AND UNIFORM GAS PRESSURE
HOLES ON ALL SIDES KEEP PRESSURE EQUAL INSIDE AND OUT, ALSO INCREASE AREA WITH BURNING
HOLE THROUGHOUT LENGTH OF GRAIN
A
PLASTIC SUPPORT WASHER
B
FIRE RESISTING PLASTIC INHIBITORS

Figure 8–3.—Rocket motor grains. A. Cylindrical. B. Cruciform.

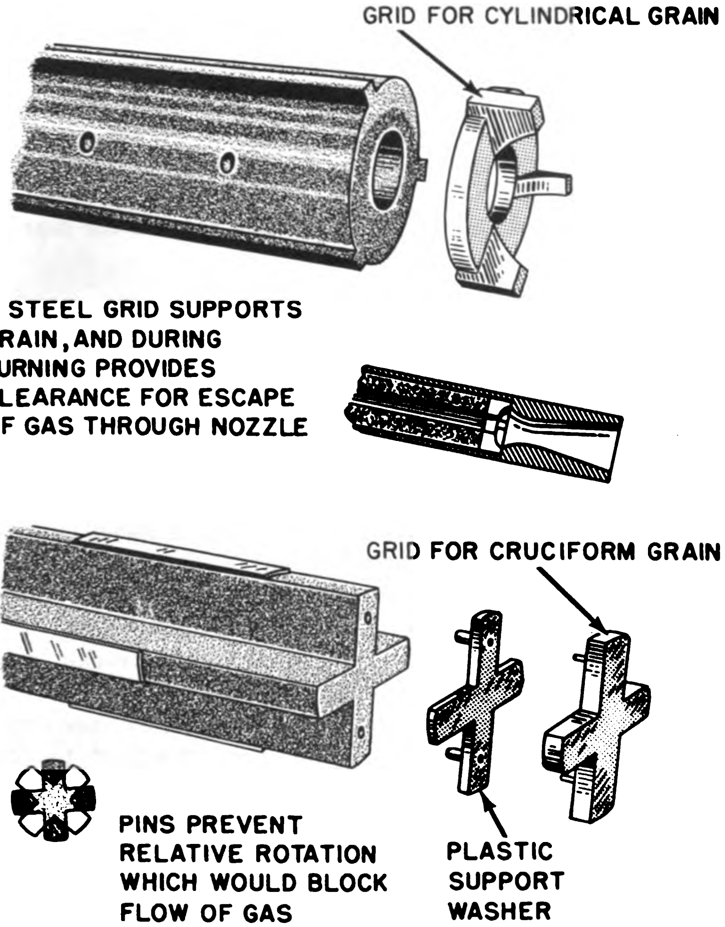

GRID FOR CYLINDRICAL GRAIN
A STEEL GRID SUPPORTS GRAIN, AND DURING BURNING PROVIDES CLEARANCE FOR ESCAPE OF GAS THROUGH NOZZLE
GRID FOR CRUCIFORM GRAIN
PINS PREVENT RELATIVE ROTATION WHICH WOULD BLOCK FLOW OF GAS
PLASTIC SUPPORT WASHER

Figure 8–4.—Rocket motor grids.

shroud around the fins, it supports the rear end of the rocket in the launcher.

Most newer rockets are SPIN-STABILIZED; that is, their nozzles are canted to exert torque as well as forward thrust. The result is that the rocket spins like a gun projectile in flight. Such rockets, of course, have no fins.

Some Navy ground and shipboard rocket motors are sealed by fiber CLOSURE DISCS, to keep moisture out and to hold the propellant in. All aircraft rockets and spin-stabilized rockets are sealed by metal closure discs.

Aircraft and spin-stabilized rocket motors are further sealed in shipment and storage by front and rear SHIPPING CAPS. The caps at the front end must be removed for assembly and use of the motors. The caps at the rear are blown out when the rocket is fired.

4.5-inch Rockets and Launchers

The 4.5-inch rocket (fig. 8–5) is a fin-stabilized general-purpose rocket, used primarily in laying down barrages in the course of landing operations. A variety of launchers has been developed for this rocket, ranging from comparatively small portable types to multirail launchers bolted or welded to the decks of ships. Range of this rocket is about 1,000 yards.

The motor of the 4.5-inch rocket is housed in a steel tube 2.25 inches in diameter and 15.5 inches long. The forward end of the motor tube screws to the rocket head, and the after end carries the shroud and fins.

The propellant is a single longitudinally perforated cylindrical grain of extruded ballistite, designed to burn uniformly on all surfaces. A pair of insulated wires leads from the shrouds to the black-powder igniter and firing squib at the forward end of the motor tube. The shrouds serve as electrical contacts with the launcher.

A grid forms a bearing surface for the after end of the powder grain. Both ends of the motor tube are sealed by discs; the one at the after end is the NOZZLE CLOSURE DISC. When the motor is fired, the nozzle closure disc and lead wires are blown out of the nozzle. A tagged safety clip, placed on the forward shroud at the time of manufacture, short-circuits the two shrouds and prevents accidental firing of the rocket by static or power discharge through the igniter during handling.

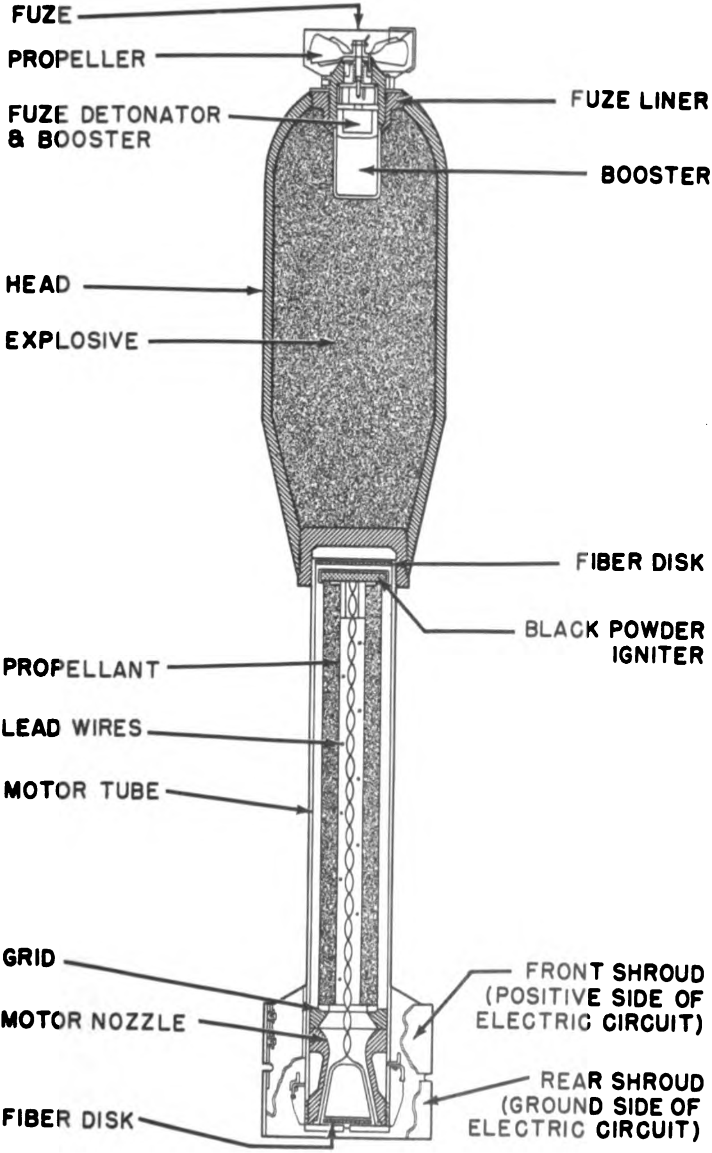


Figure 8–5.—Cross section of a 4.5-inch rocket.

The 4.5-inch rocket is fired by a firing circuit energized from ship's power system, batteries, or a magneto. When the circuit is closed, the current fires the squib and igniter; then the flame from the black powder surrounds the propellant, igniting the latter nearly simultaneously on all exposed surfaces.

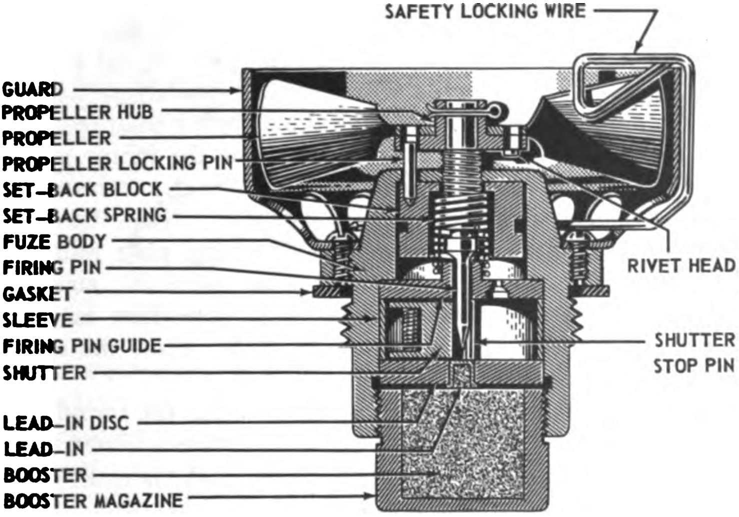
The charge in the head of a 4.5-inch rocket consists of a 6.5-pound filler of TNT and a 0.1-pound booster charge of granulated TNT. A point-detonating fuze Mk 137 (instantaneous) or Mk 145 (0.02 second delay) is commonly used on this rocket. Except for the delay feature in Mk 145, both fuzes are similar.

The Mk 137 fuze is propeller-armed and detonates the charge upon impact. Figure 8-6 shows this fuze with its components in the unarmed position. Its explosive train consists of a DETONATOR in the spring-loaded movable block called the SHUTTER, a BOOSTER LEAD-IN, and a BOOSTER. When unarmed, the FIRING PIN holds the shutter so that the detonator is out of line with the firing pin and the lead-in. An accidental explosion of the detonator will then dissipate harmlessly through a hole in the firing-pin guide. The PROPELLER OR VANE is attached to the upper end of the firing pin which is screwed into the fuze body. A propeller lock pin fits into a hole in the propeller hub to prevent propeller rotation. The pin is attached to a SETBACK BLOCK which is held forward by a setback spring. SAFETY LOCKING WIRE locks the setback block and the propeller. This wire must be withdrawn when the rocket is about to be placed in the launcher.

Upon firing the rocket, the setback block moves aft, against the setback spring, and withdraws the propeller lock pin from the hole in the propeller hub. Now the propeller rotates; this unscrews the firing pin until an unthreaded section is reached and a shoulder on the pin meets the top of the fuze body. After the firing pin is withdrawn, a spring swings the shutter into armed position, in which it locks. The detonator now is in line with the firing pin and booster lead-in, and the fuze is fully armed. Impact drives the firing pin inward (shearing the threads in the case) into the detonator, whose explosion, through the booster and auxiliary booster charge, sets off the main charge.

Before each fuze is installed in the rocket, it should be examined to see if the arming vane has unscrewed so that the forward tips of the vanes extend out beyond the plane of the rim of the vane guard. A fuze in this condition should be considered armed. Tape the vanes so that they cannot move. Dispose of the fuze by lowering it gently into deep water.

If the vanes are below the rim of the vane guard, remove the safety wire and try to turn the vanes CLOCKWISE (when



UNARMED POSITION

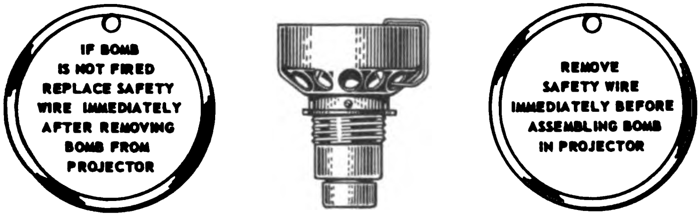


Figure 8-6.—Rocket nose fuze Mk 137.

looking at the fuze nose) to see whether the vanes are locked by the vane locking pin. Do NOT TURN THE VANES MORE THAN ONE-HALF TURN. If the vanes CAN be turned, consider the fuze armed and dispose of it. If the vanes CANNOT be turned clockwise, try to turn them the other way. If the vanes CANNOT turn at all, replace the safety wire; the fuze is safe. If the vanes CAN be turned counterclockwise, turn them one-half turn and see that the vane locking pin snaps into the nearest hole in the vane hub. Then replace the safety wire; the fuze is safe.

Do not open the sealed metal containers in which these fuzes are shipped for the sole purpose of checking the fuzes. The checking should be done when the cans are opened for installing the fuze in the rocket head.

Rocket heads and motors are usually packed and shipped separately. To assemble the complete round of 4.5-inch rocket ammunition, first remove the shipping plug from the motor adapter on the head. Then screw the motor in and tighten with a strap wrench; at least 1 inch of the motor threads must engage the motor adapter. Next, hold the rocket nose upward; remove the shipping plug and any packing from the fuze liner and make sure the auxiliary booster pellet is in place. Then screw the fuze into the liner and tighten with a spanner wrench. Stow the rocket in a ready service box.

The motor shorting wire is removed when the round is to be placed in the launcher. Fuze safety wires ordinarily are not removed until the round is in place on the launcher.

Disassembly of the rocket reverses the preceding steps. Fuzing or defuzing MUST be done by personnel familiar with appropriate ordnance publications.

Figure 8–7 shows one of the several types of launchers used for firing 4.5-inch rockets. This type, the Mk 7, is designed for use on the decks of landing craft. The Mk 7 is a gravity-feed, automatic launcher with one firing rail. Fully loaded, it holds twelve 4.5-inch rockets, which may be fired singly or automatically.

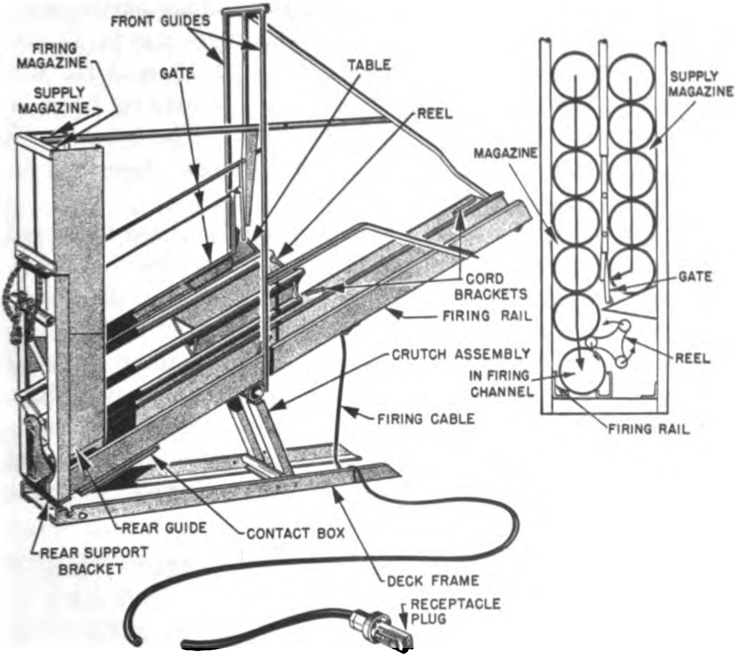


Figure 8–7.—The 4.5-inch rocket launcher Mk 7.

In automatic fire, the Mk 7 launcher will handle 12 rounds in 3 or 4 seconds. It has a crutch and deck frame for mounting on the deck. (An adapter kit fits it for mounting outboard of a landing craft.) The FIRING RAIL consists of two steel sections which hold the rocket in firing position, and two knife-edge electrical contacts. A REEL above the firing rail delivers succeeding rockets into the firing channel. As shown in figure 8–7, the left side of the magazine feeds first; when it is empty, the gate admits rockets from the right side.

5.0-inch Spin-Stabilized Rockets

Rockets of this type are designed for shipboard use. Several launchers or launcher assemblies have been developed for them. The general-purpose (Mk 7 Mod 0) and common

(Mk 24 Mod 0) rounds have large motors and are particularly well adapted for PT boat attacks at ranges up to 11,000 yards. The high-capacity rounds (Mks 10, 13, and 16, and their mods) have shorter motors and are intended for barrage use at ranges of from 3,000 to 5,000 yards. The 5.0-inch SS rocket is at present replacing the 4.5 rockets described in the preceding article.

The 5.0-inch rocket motor Mk 3 and mods is used to propel common and general-purpose 5.0-inch spin-stabilized rockets. The MOTOR TUBE, 22 inches long and 5 inches in diameter, contains a 10-pound inhibited cruciform grain of ballistite as a propellant. The tube has internal threads and an external bourrelet ring at each end, and a shipping cap screwed into the front end. The front closure, a sheet-metal disc, seals the front end of the motor tube, and holds the IGNITER and propellant in place. The igniter is a flat, tinned case con-

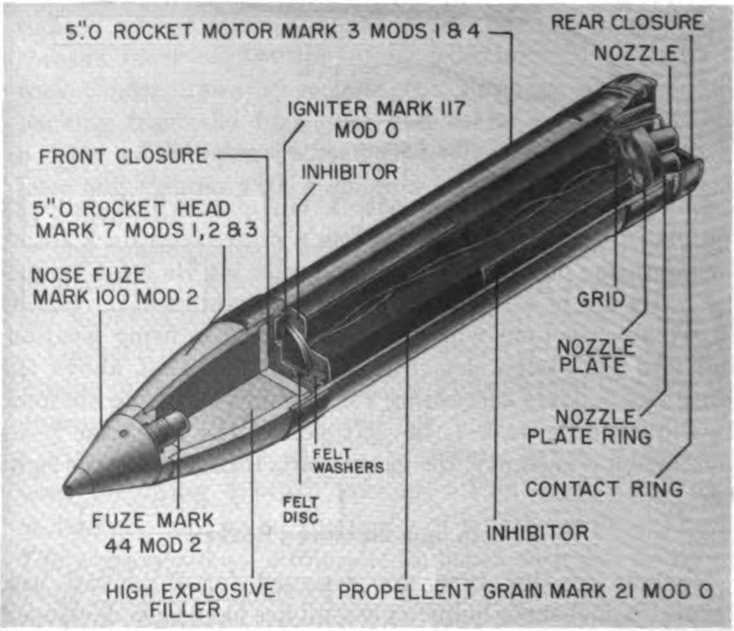


Figure 8-8.—The 5.0-inch rocket Mk 7 Mod 2 (surface general-purpose SS).

taining 35 grams of black powder and an electric squib. Two wires from the squib to the rear of the motor tube connect, respectively, with the contact ring and the motor tube (ground) at the nozzle ring plate. A felt washer forward of the propellant grain protects against accidental shock.

The NOZZLE ASSEMBLY is screwed into the after end of the motor tube and staked in place. It contains a GRID to support the propellent grain, four or eight NOZZLES, the TERMINALS of the igniter electrical circuit, and the INSULATED CONTACT RING. The NOZZLES are arranged in a circle and are canted to spin the rocket clockwise in flight (as viewed from the rear). The INSULATED CONTACT RING is a continuous steel band encircling the rear section of the nozzle assembly and insulated from it by a plastic sleeve. One terminal of the igniter electrical circuit is connected to it and is the live contact. The other is grounded to the nozzle assembly and, through it, to the motor tube resting on the grounded launcher. A short-circuiting band protects the igniter against accidental detonation by stray currents. The band is removed just before firing. The motor tube after end is sealed by a thin metal disc cemented in place in the rear of the nozzle assembly. Front and rear closures of the motor tube should remain in place at all times. If a closure has been broken, the motor should be turned over to an ammunition depot or disposed of by lowering into deep water. The shipping cover or motor thread protector, however, must be removed when the complete round is assembled.

Motors Mks 4, 5, and 6 are similar in construction, except that they are shorter in length.

Rocket head Mk 7 and mods is the general-purpose head for 5.0-inch spin-stabilized rockets. (Figure 8–8.) It contains 2.8 pounds of TNT as a burster. When shipped, the head is protected by a nose shipping plug and a base shipping cap. The head's after end is threaded for assembly to the motor Mk 3. Mounted on the head's forward end are an adapter and the auxiliary detonating fuze Mk 44 Mod 2. When assembling the complete round, remove the shipping plug before screwing the Mk 100 nose fuze into the adapter.

The nose fuze Mk 100 is a selective-action type armed by rotation during flight. A SELECTOR in the side of the fuze body may be turned to DELAY or SQ (superquick). The amount of delay incorporated is 0.025 second.

Other heads for 5.0-inch spin-stabilized rockets include the Mk 8 (common), the Mks 10, 12, and 13 (high-capacity), and the inert-filled Mk 10 and mods (practice). The Mk 8 contains a 1.7-pound bursting charge of Explosive D and is unusual in that it is shipped with its Mk 31 base-detonating fuze in place, protected by a shipping cap. Like most other fuzes for 5.0-inch spin-stabilized rockets, this fuze is armed by centrifugal force developed by rocket rotation, and is detonated on impact.

No attempt to remove this fuze may be made except by authorized bomb disposal personnel.

The motors of 5.0-inch spin-stabilized rockets should be stowed in the shipping containers or tanks in which issued, in smokeless-powder magazines where temperatures are maintained below 90° F. Prolonged stowage at 100° F or higher is considered to be hazardous. Motors should not be stowed in the same compartment with or near electronic apparatus or antenna leads.

At the discretion of the commanding officer, READY SERVICE ROUNDS (assembled and fuzed) may be stowed with the rounds pointing outboard if practicable. Because the rocket will, if the motor fires, attain full rotational velocity whether in the launcher or not, its fuze will arm. Therefore, 5.0-inch high-capacity and general-purpose rockets should not be fuzed until as late as possible before firing.

Like other rockets, 5.0-inch SS rockets should be kept in the shade, and should not be fired if motors have been exposed more than an hour to temperatures outside the safe temperature limits specified on the motor tubes.

Since you will be responsible for the efficient and safe assembly and disassembly of 5.0-inch rockets, you should know the proper loading procedure and be able to train your men in it. The proper tools—two special 5.0-inch spanner wrenches and a special quick-action vise—are in the Mk 2 Mod 0 assembly kit shown in figure 8–9. (Strap wrenches and bench clamps may be used if the kit is not available.)

Here in brief is the assembly procedure: Bolt the vise to a bench and use it to hold the motors. Take up the head of the first round to be assembled; remove the thread protector cap. (If it's a Mk 8 common head, check to see that the base fuze is in place. Minus its fuze, such a head will detonate as soon as the motor is fired. If the fuze is not in place, dispose of the head.)

Next, remove the thread protector from the motor's forward end. (Do not remove the other closures, the felt washers, or the short-circuiting band.) Make sure the threads to be mated on both motor and head are clean; then secure the motor in the vise, and screw on the head by hand. Be careful not to cross threads. Tighten the head with the spanner wrench, as in figure 8–9.

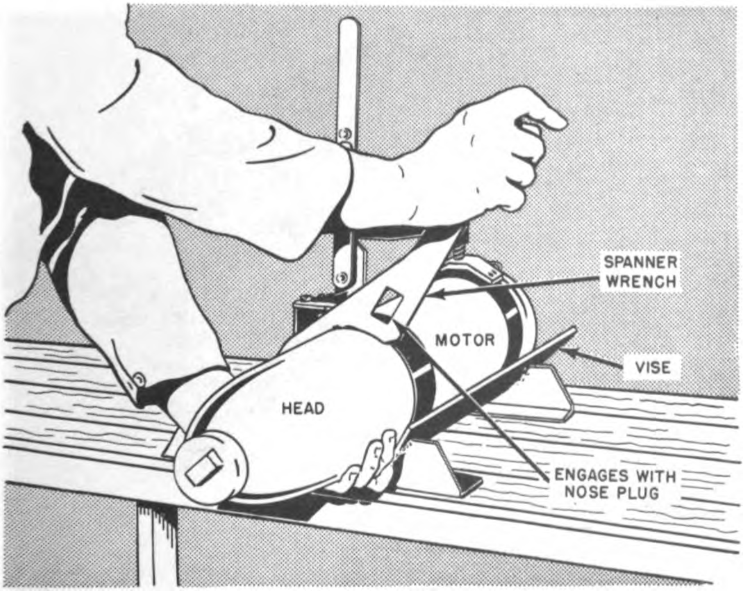


Figure 8–9.—Assembling a 5.0-inch SS rocket: Tightening head with spanner wrench.

On nose-fuzed heads, next remove the nose plug and assemble the fuze wrench-tight, using the special wrench supplied in each box of fuzes. Wipe the grease off the bourrelets and contact ring. The short-circuiting band should remain in place until just before the rocket is loaded into the launcher.

BuOrd issues a rocket circuit continuity tester for checking the 5.0-inch rocket motor electrical circuit. This tester must NOT, however, be used for this purpose aboard ship.

For further detail on 5.0-inch SS rockets, see OP 1260.

5.0-inch SS Rocket Launchers

The two 5.0-inch SS rocket launchers that we shall take up here are the Mk 50 and the Mk 102. The Mk 50 is an 8-tube launcher designed for use on PT boats. Two are mounted on each boat. Their elevation is adjustable, and they may be swung inboard for loading and outboard for

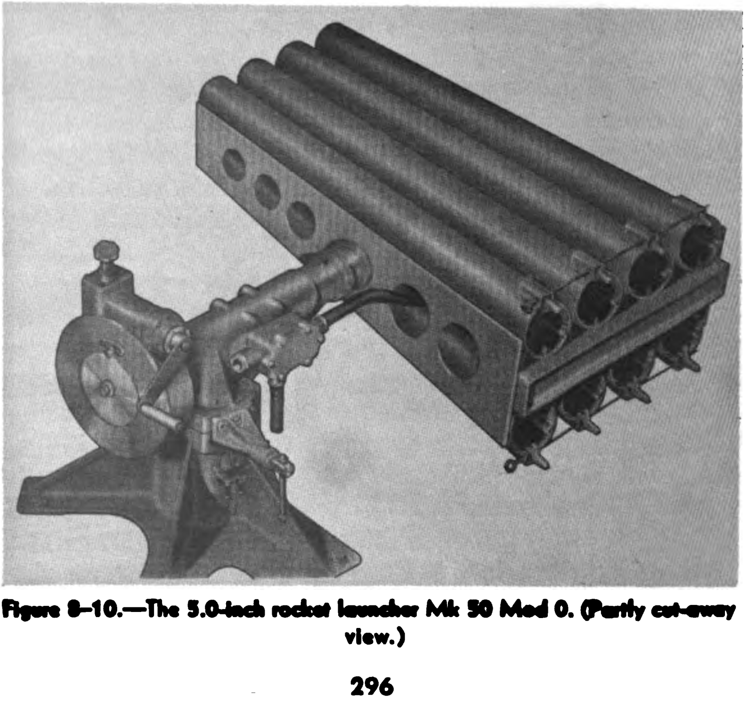
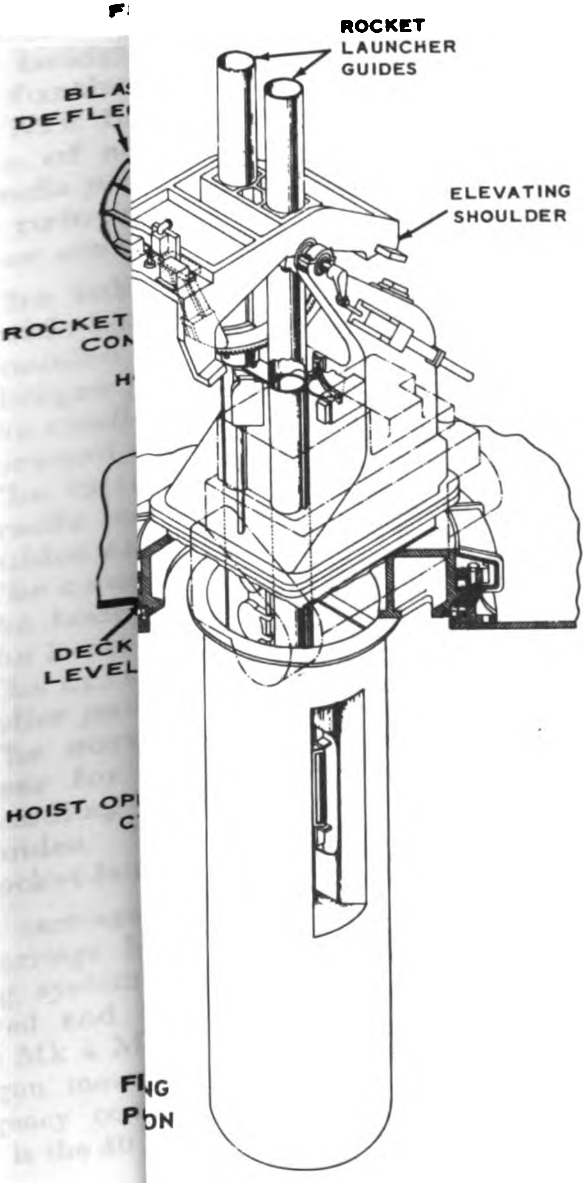


Figure 8–10.—The 5.0-inch rocket launcher Mk 50 Mod 0. (Partly cut-away view.)



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firing, but cannot be trained for firing. The barrels are arranged in two rows of four each, one row above and the other below a horizontal supporting shaft. A firing button on the bridge fires one rocket at a time from each launcher.

For further detail on the Mk 50 launcher, see OP 1244.

The Mk 102 launcher, designed for use on landing craft, is capable of automatic fire of rockets at a sustained rate of 30 rounds per minute.

The principal components of the Mk 102 Mod 0 rocket-launcher assembly (fig. 8–11) are as follows:

1. The tubular ROCKET-LAUNCHER GUIDES, mounted in a guide housing which moves hydraulically from a vertical position in line with the hoist tubes for loading, to an oblique position in line with the elevating shoulder of the cradle for firing, and back again to reload. Mounted forward on the guides is a blast shield (not shown).
2. The CRADLE which supports the launcher guides. The cradle includes the elevating shoulder which holds the guides at firing elevation.
3. The CARRIAGE ASSEMBLY which supports the cradle and the train and elevating power drives above decks and the hoist below decks.
4. The STAND which is fixed to the deck and supports the roller path.
5. The HOIST which consists of two tubes and hydraulic gear for simultaneous lifting of two rockets from a handling room below deck into the rocket-launcher guides. The hoist rotates in train with the rest of the rocket-launcher assembly.

The carriage of this assembly is an adaptation of a 40 mm carriage Mk 1 Mod 2, with guns, firing mechanisms, cooling system, loader's platform, and other components removed and others added. Train and elevation power drives Mk 4 Mod 3 are the same as those used with the 40 mm gun mount, except that several train and elevation emergency control push buttons have been added. The stand is the 40 mm stand Mk 1.

The Mk 102 Mod 0 launcher is remotely controlled by a director fire control system. A firing stop mechanism prevents firing into ship's own structures. In automatic firing, the loading of two rockets into the hoist tubes in the handling room below decks initiates the operating cycle which includes the following steps:

1. Hoist lifters.
2. Lower lifters and move rocket guides to firing position.
3. Fire.
4. Move guides to loading position.

The hoists can then be reloaded and the cycle repeated.

Each step in this cycle is timed and controlled by mechanically actuated switches. The INTERVALOMETER, a device in the firing circuit, introduces a 0.66-second delay between the firing of two rockets, to avoid blast interference. A safety interlock prevents the rocket-launcher guides from returning to reloading position until the rockets fired from both guides are clear.

Further detail on the Mk 102 launcher appears in OP 1424.

7.2-INCH ROCKETS AND LAUNCHERS

One of the most serious problems that the Navy has been faced with in both World Wars is the submarine. World War I saw the development of the depth charge. Depth charges (and their cousins, depth bombs) constitute one of the major types of weapons so far developed for antisubmarine warfare. The other major type of weapon for attacking submarines is the THROWN MISSILE.

The main advantage of the thrown missile is that it permits immediate attack against the submarine when it is detected. It is not necessary (as it is with depth charges) for the A/S ship to pass above the sub before attacking. Thus slower ships can engage submarines, and attacks are more likely to be successful.

The first ahead-thrown missile put in service by the Navy was the 7.2-inch rocket with its associated rocket launcher Mk 20 (fig. 8–12, *A*) formerly known as the "mousetrap."

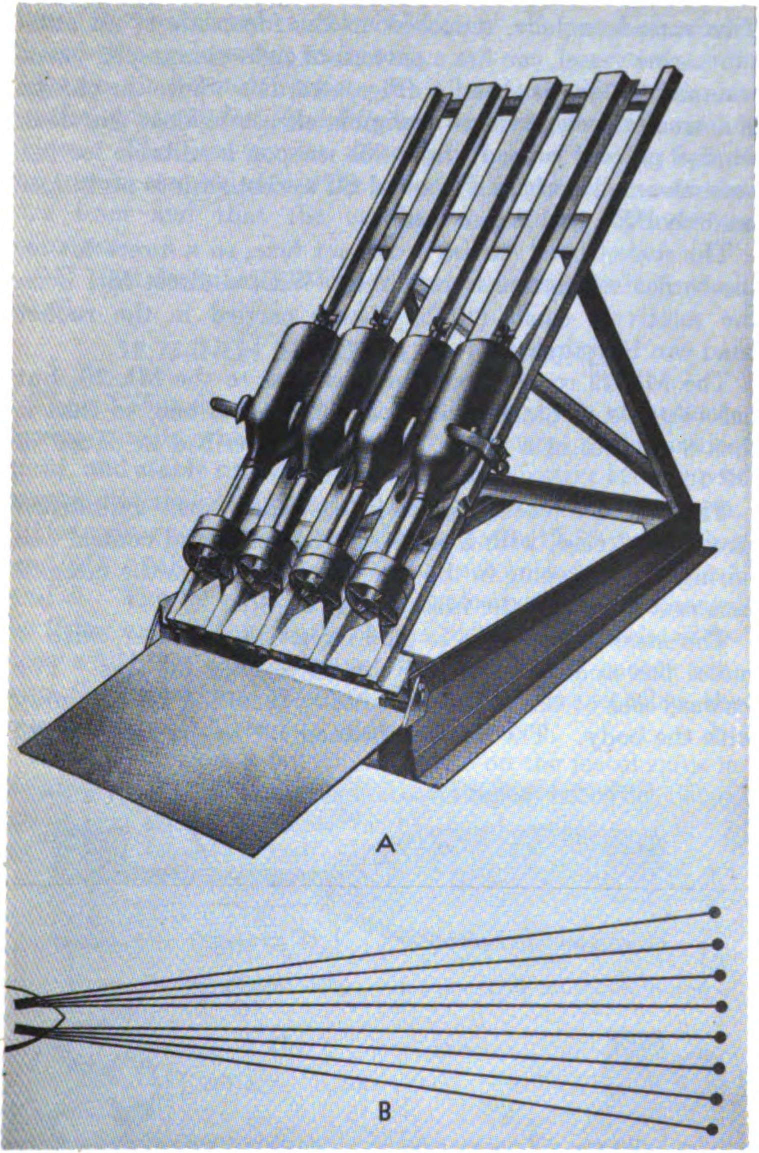


Figure 8–12.—The 7.2-inch rocket launcher Mk 20. A. Loaded launcher. B. Pattern of salvo.

Two such launchers, mounted on the forecastle of an antisubmarine vessel, can fire a pattern of eight charges, 83 yards wide and 300 yards ahead. (Fig. 8–12, *B*.) Since the charge is a true rocket, there is negligible thrust against the deck when a pattern is fired; thus, this weapon is suitable for use on such small craft as PC's and SC's, though it is no longer used on DE's and larger vessels.

The rocket head carries a contact fuze, so a direct hit on the target submarine is required. With a direct hit, even the relatively small (30-lb) charge carried in the rocket head can be lethal.

The Mk 22 rocket launcher is similar to the Mk 20, but has two sets of hinged steel ways instead of one, so that it fires 8 rockets in a salvo. Both are described in detail in OP 1002.

The 7.2-inch rocket head is a welded steel cylindrical streamlined case, with a relatively flat nose and conical tail fairing. An opening in the nose section receives the integral fuze seat liner and the fuze. (Fig. 8–13.)

The steel motor tube is 2.25 inches in diameter, with 4 radial fins and a cylindrical shroud around the fins. The forward end of the tube is externally threaded for assembly with the body. The fins are inclined 10° to the tube axis to

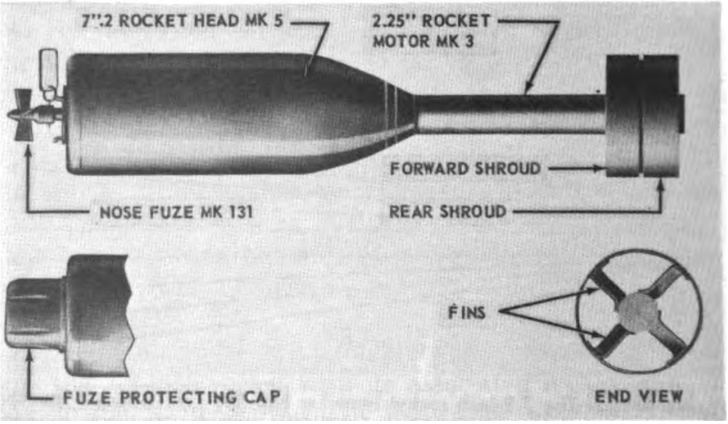


Figure 8–13.—The 7.2-inch rocket.

rotate the rocket and cancel "ruddering" effects which would disturb the underwater trajectory.

Fuzes for 7.2-inch rockets are all hydrostatic-arming at depths of 8 to 30 feet, and function upon impact with a solid object. The fuze screws directly into the head. Before the fuze is assembled, see that the auxiliary booster is in the fuze liner and that the cardboard shipping cylinder is removed.

OP 1002 describes 7.2-inch rocket ammunition in further detail.

12.75-INCH ROCKET AND LAUNCHER

The 12.75-inch rocket Mk 1 Mod 0 (ASP) is an antisubmarine missile whose relatively great range, rapid sinking speed, and stable trajectory permit more effective attack over larger areas against submarine targets than do depth charges.

The rocket consists of two main parts, the 12.75-inch rocket head Mk 1 (all mods), and the 5.25-inch rocket motor Mk 1 Mod 0. The head contains the explosive bursting charge, the firing mechanism depth, charge pistol, and associated devices which set the explosive off. The rocket motor contains the propellant. Its tail shroud and fins stabilize the round during air flight and underwater travel.

When the rocket is launched, a vane on the pistol spins in the air stream. This operates an arming device which closes one of two arming switches in the pistol, making the firing mechanism sensitive, and unlocks the extender. Continued spinning of the vane causes the arming device to jettison while the rocket is still in the air. When the rocket hits the water, water pressure can operate the extender to rotate the detonator to armed position, and complete the electrical arming circuit.

The functioning of the firing mechanism depends on the distortion of the earth's magnetic field by any object of magnetic material, such as iron or steel. (Certain mines, mentioned elsewhere in this course, also function on this principle.) When the armed rocket comes within close range of the submarine, the submarine's effect on the earth's magnetic

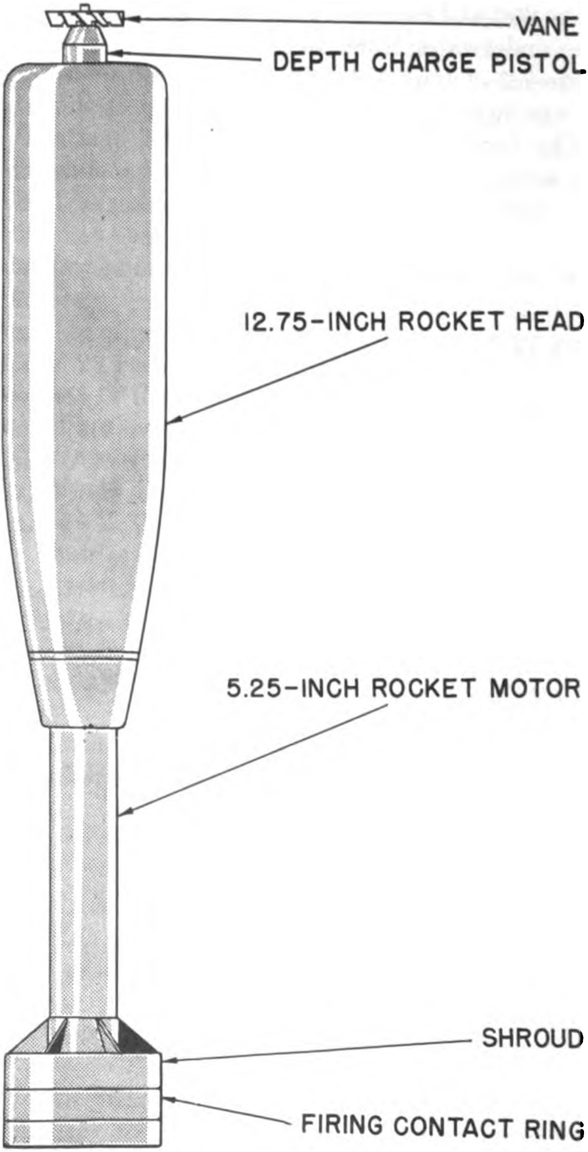


Figure 8-14.—The 12.75-inch A/S rocket Mk 1 Mod 0.

field causes the mechanism to receive a "look." As the rocket passes the submarine, it receives a reverse "look" produced by a reverse change in the earth's magnetic field. It is the second "look" that causes the rocket to explode.

Though the projectiles for the Mk 108 launcher are true rockets, the construction, operation, and even the appearance of the launcher and its mount resemble those of a medium caliber gun mount. Figure 8–15 shows the Mk 108 launcher in cross section as it would be actually installed on a ship. The launcher incorporates an ammunition supply system comparable in extent to that of a 5.0-inch twin mount. We can get a good over-all view of its operations by following the ammunition supply path upward from the magazine.

First of all, the lower magazine crew takes a round out of stowage and, with a whip hoist, loads it into the tray (shown in horizontal position) at the lower end of the lower ammunition hoist. An electrohydraulic mechanism raises the tray (which is hinged at its left end, as shown in the figure) until the round is placed in the hoist lower end, tail down.

Then the electrohydraulic ram lift in the hoist raises the round to the rocket launcher ready service magazine. This is a large circular drum that can be rotated like a merry-go-round around its vertical axis by an electrohydraulic power drive. The round being loaded is hoisted into one of 22 vertical guides in the magazine. The "merry-go-round" then rotates automatically just enough to line up the next empty ammunition space with the lower hoist, ready for the next round it will deliver. Meanwhile, the lower hoist lifter returns to the lower handling room and the tray lowers to its initial position, ready to be loaded with the next round. Then the process repeats until the desired number of rockets has been loaded, or until the magazine is full. (It can hold 22 rounds.)

When firing is to begin, the mount is first cast loose—the proper switches must be set, the power drives energized and checked, the launcher mount must be synchronized with the director, and so on. (If you are assigned to work with this launcher, you will have preliminary training, and you will

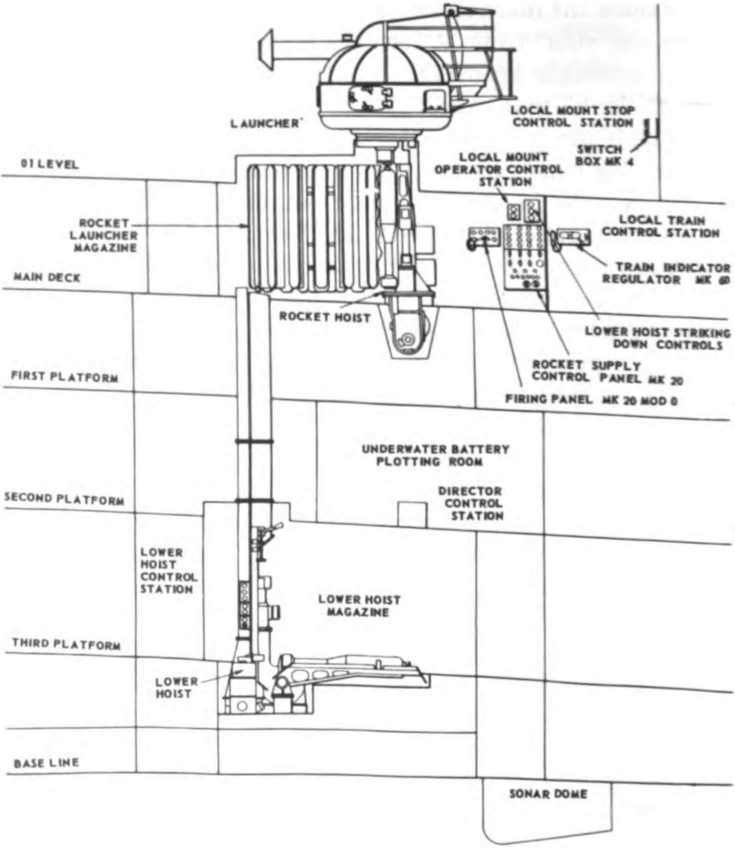

LAUNCHER
LOCAL MOUNT STOP CONTROL STATION
SWITCH BOX MK 4
01 LEVEL
LOCAL MOUNT OPERATOR CONTROL STATION
ROCKET LAUNCHER MAGAZINE
LOCAL TRAIN CONTROL STATION
TRAIN INDICATOR REGULATOR MK 60
MAIN DECK
ROCKET HOIST
LOWER HOIST STRIKING DOWN CONTROLS
ROCKET SUPPLY CONTROL PANEL MK 20
FIRST PLATFORM
FIRING PANEL MK 20 MOD 0
UNDERWATER BATTERY PLOTTING ROOM
DIRECTOR CONTROL STATION
SECOND PLATFORM
LOWER HOIST CONTROL STATION
LOWER HOIST MAGAZINE
THIRD PLATFORM
LOWER HOIST
BASE LINE
SONAR DOME

Figure 8–15.—The 12.75-inch rocket launcher Mk 108.

study OP 1754 to get the full details on it.) When casting-loose operations are completed, and the magazine is loaded, and controls are set for underwater battery plot to take over launching of rockets, all deck personnel must retreat to safety stations. Only then can launching begin. To transfer a round of ammunition to the launcher, the ready service magazine is first rotated until one of its loaded rocket guides is directly under the launcher's rocket hoist mechanism. The rocket-launcher tube is in loading position (90° elevation). In this position, which coincides with the axis of train of the launcher mount, the tube is directly over the rocket hoist, so that, as the hoist lifts the rocket, the rocket enters directly into the tube until it latches there. The tube remains vertical until the hoist lowers enough to clear it, whereupon the tube is driven by the elevation power drive to the elevation transmitted by underwater plot through the director. When the tube reaches the transmitted elevation, it can be fired by the firing circuit from the director. The firing circuit is connected to the rocket's squib through contact units in the launcher which touch insulated metal surfaces on the rocket shroud when the rocket is in the tube. The circuit is completed from the squib to ground through the body of the shroud itself.

After the rocket leaves the tube, a bore clear mechanism initiates elevation power drive functioning to elevate the launcher tube to loading (vertical) position.

The rocket exhaust is deflected back up through a flame-resistant chamber and up an exhaust port in the shield. Power blowers running constantly keep the temperature in this chamber within controllable limits. However, the rocket guide tube gets so hot that the danger of cook-off in case of misfire is very great, and the tube must be flushed immediately with water in case a round does misfire.

The launcher's firing rate is 12 rounds per minute, which will exhaust the ready service magazine in less than 2 minutes at maximum firing rate. Note that the magazine cannot be loaded while firing is going on.

If you are assigned to a ship armed with this launcher, use the following as sources of further information on it and its ammunition:

OP 1754—Rocket Launcher Mk 108
OP 1792—12.75″ Rocket Mk 1 Mod 0
NavShips 378-0123—Lower Rocket Hoist

Safety Precautions With Rockets

Nozzle blast from a rocket motor is intensely hot. Small pieces of burning powder, smoldering felt washers, and the like, frequently are blown out of the nozzles and may be hard to extinguish. Suitable steel sheathing is therefore used to protect decks and superstructure areas around launchers. Some launchers have blast deflectors for protection of the immediate area; others are mounted slightly outboard, so that blast is directed into the water. Obviously, then, you must see that no one EVER is directly in front of or behind a loaded launcher or one that is being loaded. Personnel loading a launcher should always stand to one side of the path that would be taken by rocket or blast in the event of accidental or intentional firing. Moreover, all personnel in the vicinity of a launcher should wear long trousers and long shirt sleeves buttoned about the wrist.

The firing circuit must be kept disconnected at all times until the launcher is ready to fire. Be sure the safety plug is out during loading. All extra rockets must be kept at a safe distance from a loaded launcher. No one may approach a loaded launcher until the safety plug or firing key has been removed from the firing circuit. The fuze safety wire must be reinserted as soon as the safety plug or firing key has been removed—but not before. No test of the firing circuit may be conducted until all rockets have been removed from the launcher and placed at a safe distance.

In stowing rockets, control of temperature is just as important as with smokeless powder. However, that control is often harder to maintain, because rockets in launchers and in ready service must so often be exposed to extremes of heat and of cold. (The latter is so rare with smokeless powder that usually it is not a problem.) Prolonged exposure to temperatures over 100° F can make ballistite oversensitive and likely to detonate rather than burn smoothly as a well-behaved propellant should. Exposure to extremely low temperatures (0° F or below) will make the rocket erratic ballistically. (These temperatures refer to the actual temperature of the rocket motor itself, not to the general air temperature.) Rocket motors can get pretty hot when exposed to sunlight, even if the air itself is not uncomfortably hot. When danger of overheating exists, therefore, see that your rockets are kept under cover.

Individual marks and mods of rockets vary in their sensitivity to heat, and often have their own special quirks that personnel stowing and handling them must know. (For example, 5.0-inch SS rockets mustn't be left standing on their bases for over an hour.) It is therefore important to read the instructions printed on the motor tube, and to follow them to the letter. Also see NavOrd Instruction 8010.2 on this.

One aspect in which rockets differ radically from gun ammunition is in their sensitivity to stray electric currents. Because almost any stray current can initiate an electric squib, all rocket motor firing leads or contacts MUST be kept short-circuited until the round is about to be loaded into the launcher. Dangerous stray currents may be induced in shorted circuits by electromagnetic waves of sufficient power; therefore, even short-circuiting is no infallible preventive. Rocket motors must NEVER be stowed in the same compartment with functioning radio or radar apparatus.

You know that rocket motors must not be assembled to their heads until they are about to be loaded into their launchers or put into ready service stowage. Fuzes are usually installed at that time also (though there are exceptions). For precautions to be observed when your men are assembling complete rounds, you should consult the current OP's, OCL's, and other directives on the ammunition. However, here is a brief checklist of safety measures that are generally applicable.

1. Motors of current rocket assemblies are threaded to engage their heads. Avoid cross-threading; the assembly must be tightened with the prescribed tools. On 5.0-inch SS rockets, do not remove front and rear closures from Mk 3 motors when assembling.

2. Fuzes should be assembled to the heads AFTER the motors. Inspect fuzes to be sure that they are not armed. Some fuzes arm in two stages—partially and fully. From the point of view of personnel working with them, partially armed fuzes are just as dangerous as fully armed fuzes. Neither must EVER be assembled to a rocket head. Be sure your men are trained to recognize partially or fully armed

fuzes, where possible. (It is not possible to recognize arming of some fuzes just by exterior appearance.) Fuzes should be disarmed only by qualified personnel.

3. Some rocket heads (specifically, at this writing, the 5.0-inch Mk 8 common) are shipped with base-detonating fuzes in place. Others (the 4.5-inch head) come with booster pellets. In these and in all similar cases, your men must be impressed with the importance of inspecting to be sure all these components are in place as required BEFORE assembling the round. With the Mk 8 head, omission of the fuze will cause the burster to explode as soon as the propellant takes fire—probably BEFORE the round can leave the launcher.

4. In general, on hand-loaded launchers, motor shorting wires, clips, or rings should be removed just BEFORE the rocket is loaded into the launcher; fuze safety clips, safety wires, or vane covers should not be removed until the round is actually in place on the launcher.

Because of the wide variations in design of present rocket launchers—which range from the almost primitive Mk 20 (or even simpler designs) to the elaborate Mk 108 (which rivals a 5″/38 twin mount in complexity)—it is not possible to give general safety procedures for dealing with various emergencies like misfires. These you must train your crews in by using the OP's and other relevant directives aboard your ship. About all that can be said about rocket misfires in a course like this is—

1. Keep all personnel not immediately concerned clear of the launcher area. Keep them clear until the misfired round is removed.

2. Remove the safety plug. Flush the misfired round and adjacent parts of the launcher immediately with quantities of water.

3. After a 10-minute waiting period, if all immediate danger is past, the best procedure usually is to reshort-circuit the motor, reinsert the fuze safety wire, remove the round from the launcher, and LOWER the complete round into deep water.

A/S PROJECTORS

The Mk 20 rocket launchers discussed earlier in this chapter were the earliest ahead-throwing A/S weapons adopted by the U. S. Navy. On DE's and larger ships, however, they since have been displaced by A/S projectors that function on different principles—the projectors Mks 10, 11, 15, and their mods (formerly known as "hedgehogs"). The Mk 10, the earliest model to be adopted for Fleet use, will serve to illustrate the basic functioning of these types. But before we take it up, let us examine the ammunition these projectors are designed to fire—the 7.2-inch PROJECTOR CHARGE ASSEMBLY.

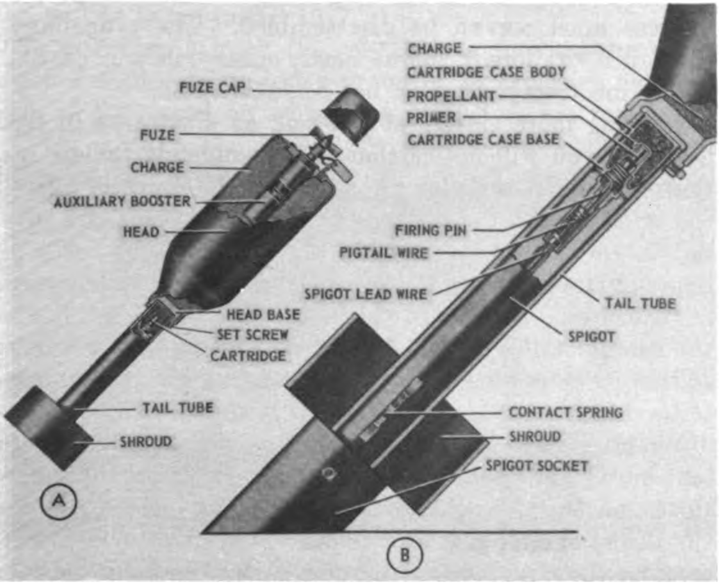


Figure 8–16.—The 7.2-inch projector charge assembly. A. Partial cross section of head and cartridge. B. Section through spigot and tail tube.

The 7.2-inch projector charge is not a rocket. Its projector, on the other hand, is not a gun, so the charge does not resemble gun ammunition. The 7.2-inch projector charge assembly consists of two main components—the steel cylindrical HEAD which contains the burster and fuze, and the steel tubular TAIL which contains the propelling charge and carries the fins and shroud. The fins are canted to rotate the projectile. The complete round is issued as one assembled unit; because the head and tail are assembled at the loading depot, where the weight of the propellant is determined by the total weight of the charge, projector charges must NEVER be disassembled. The propellant in the tail is "tailored" for its head; other tails will be ballistically incorrect, and must not be substituted.

Looking more closely at the tail, as illustrated in figure 8–16, *A*, you will notice that it is completely hollow more than five-sixths of its length, so that it slides neatly over the rod or SPIGOT of the projector. At the forward end of the tail is the smokeless powder propellent charge, which is housed in its own cartridge case, along with an electric primer at its center. Figure 8–16, *B*, shows how the spigot fits into the tubular tail when the charge is loaded on the projector, so that its spring-loaded firing pin contacts the primer, ready to be set off when the firing circuit is closed.

When that circuit is closed, the smokeless powder propellant burns, and the pressure of the hot gas it produces exerts thrust on both the charge and the spigot. However, since the thrust exerted on the spigot is merely transferred to the deck by the projector's structure, while there is nothing else to take up the thrust exerted on the projector charge, the projectile is forced up and off the spigot at considerable velocity.

Because (unlike a rocket launcher) the projector transmits considerable thrust when a salvo of charges is fired, the ship's structure must be sturdy enough to withstand the stress whose vertical component may run as high as 97,000 pounds. That is why these projectors are not found on vessels smaller than DE's.

The forward end of the 7.2-inch charge assembly head has a flat nose with an opening to receive the fuze seat liner and the fuze. The principal nose fuze used with the 7.2-inch projector charge is the Mk 158. This fuze arms partly by setback upon being fired, and is then fully armed by rotation of a vane as it travels through the water. It functions upon impact, either direct or glancing.

Projector charge fuzes that have become armed or partly armed must be made safe before disposal. Methods of doing this, and details on inspecting and installing these fuzes, will be found in OP 1017.

The projector Mk 10 (fig. 8–17) is a forward-throwing weapon designed to project a group of 24 explosive charges ahead of the vessel on which the projectors are mounted.

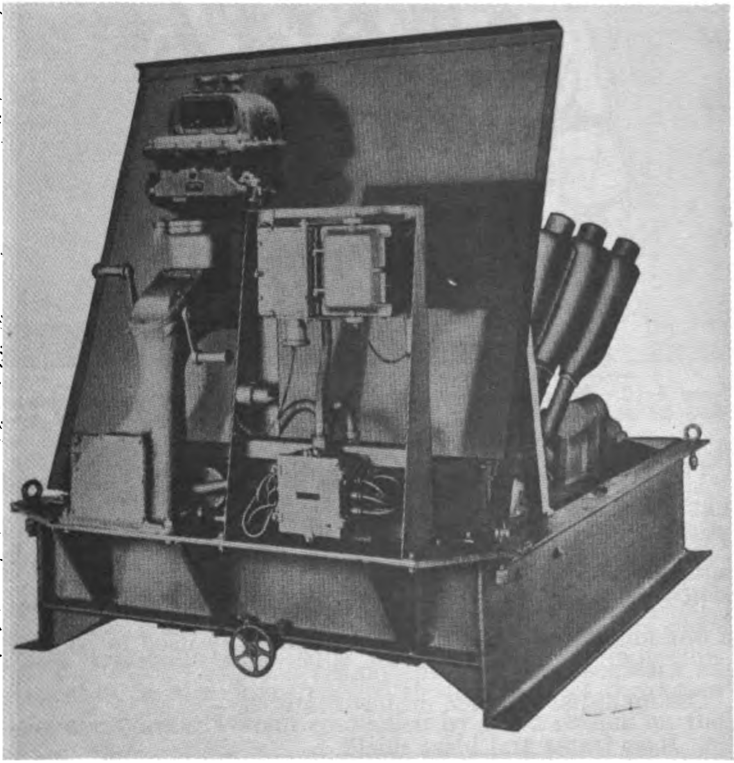


Figure 8–17.—The 7.2-inch projector Mk 10 Mod 1 or Mk 11. Rear view.

The explosive charges are mounted on 24 cylindrical SPIGOTS, as shown in figures 8–17 and 8–18. These are attached to CRADLES capable of being swung about a horizontal fore-and-aft axis by means of gearing from a gun train indicator pedestal. Port and starboard rotation about this axis compensates for the ship's roll and permits some training of the line of fire.

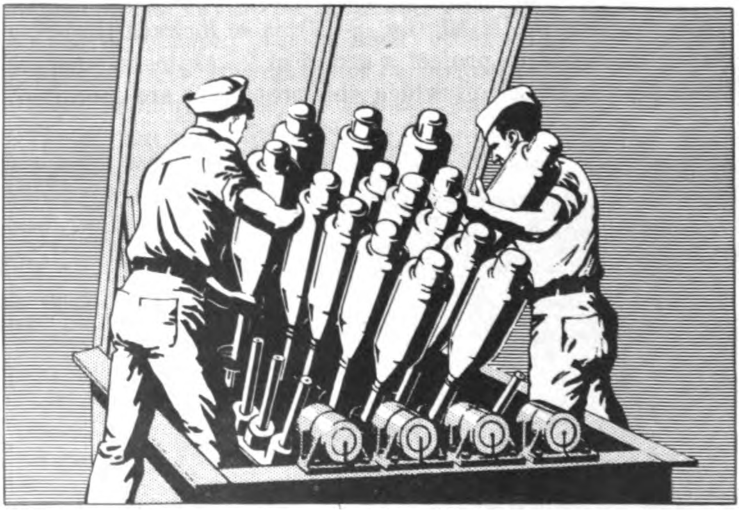


Figure 8–18.—Projector Mk 10 Mod 1 or Mk 11: Loading the inboard spigots.

The purpose of the projector is to fire the 24 charges so that they strike the water in a circular or elliptical pattern. (Fig. 8–19.) The maximum range to the mean point of impact is 185 to 200 yards when the vessel is stationary.

The projector is installed primarily aboard vessels engaged in antisubmarine activities and is generally used in connection with sound ranging equipment.

The main parts of the projector are the—

1. Base frame and blast shield.
2. Cradles and spigots.
3. Roll correction gear assembly.

The accessories used in connection with the projector are the—

1. Firing panel Mk 1 and mods and junction box.
2. Gun train indicator Mk 52 and mods.
3. Target designation transmitter Mk 8 and mods.

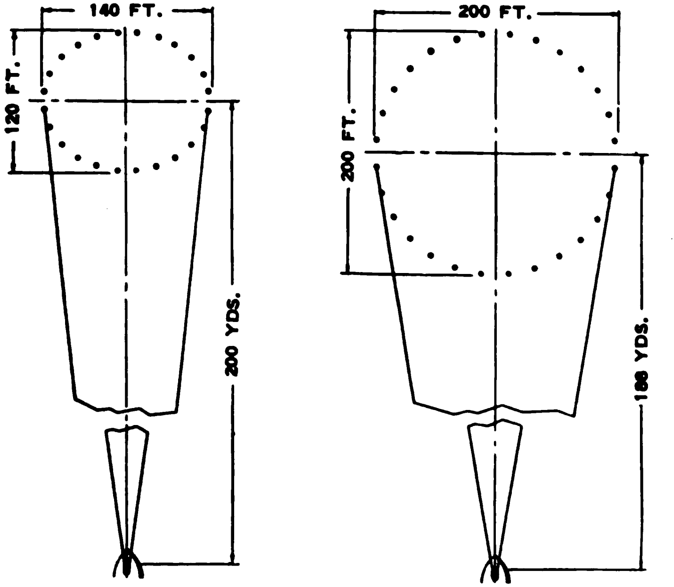


Figure 8–19.—Salvo patterns of the 7.2-inch projector: Left, Mk 10 and mods; right, Mk 11.

The projector charges are fired electrically, in pairs, through a ripple switch on the firing panel. A complete salvo consists of 24 charges fired at intervals between pairs.

Gun train bearing is manually introduced into the target designation transmitter, which converts it to tilt and electrically transmits this value to the gun train indicator. This value, in turn, is introduced to the projector through a follow-the-pointer system controlled by hand cranks on the mount.

The cradles are tilted to compensate for the ship's roll and to permit some training of the line of fire. Since tilting the cradles distorts the salvo pattern, aiming the projector should be kept to a minimum; the ship, rather than the projector, should be aimed, whenever practicable. Increasing the tilt tends to flatten the pattern until the pattern at full tilt approaches a straight line.

Another type of projector is the Mk 15 Mod 0, shown in figure 8–20. Like the projector Mk 11, it casts 24 explosive charges of the same size and type in one continuous ripple-fire action.

Improved features of this projector are arrangements that position the cradles from which the charges are fired. The cradles run across the mount (not fore-and-aft, as in Mks 10 and 11). They can be elevated or depressed by a power drive. This and a train power drive compensate for the ship's pitch and roll while following the target.

A selector for AUTOMATIC CONTROL or HAND DRIVE enables the elevating and training gear to be operated either by remote control for all normal firing operations or for drill or exercise of the equipment, or by hand drive for maintenance work, lubrication, and stowing.

The method of firing, although similar to that used in earlier projectors, includes distinctive operating features. The firing handle that operates a ripple switch device is arranged so that it can be tripped by remote control from the control plotting room.

The Mk 15 stand, carriage, and power drive components are adapted from parts produced for 40 mm quad mounts.

Further information on Mks 10 and 11 projectors will be found in OP 1001; for information on the Mk 15, see OP 1745.

Safety Precautions for A/S Projectors

The common precautions that attend work on any explosive munitions must be observed in connection with projector charges—especially since each charge is a complete round, just like fixed ammunition for guns. But here are some special precautions that any crewman working on or around the loaded projector must know. (For further de-

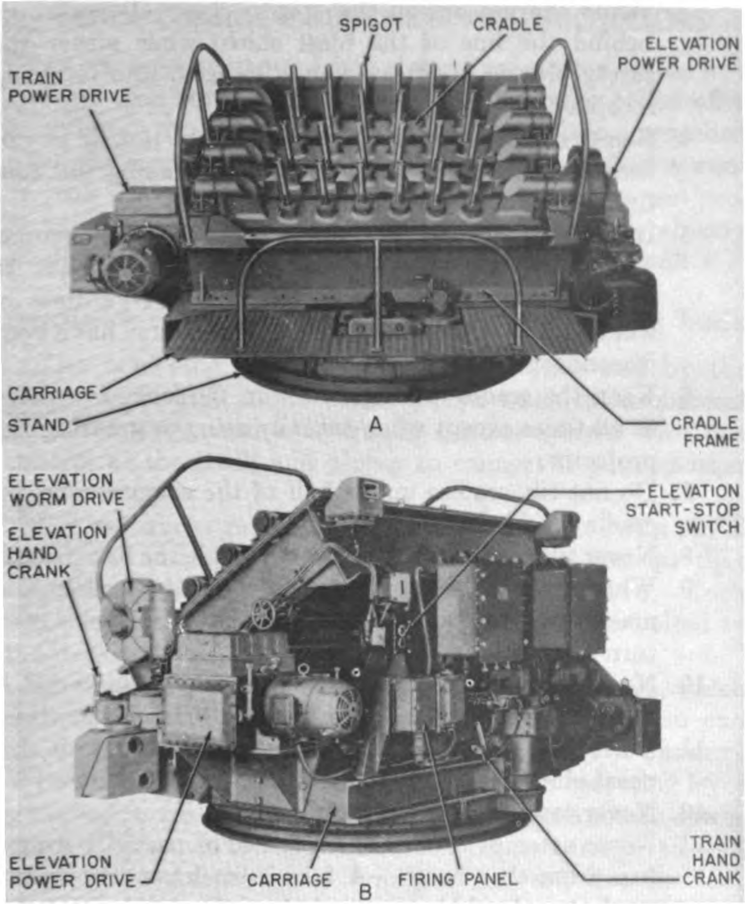


Figure 8-20.—The 7.2-inch projector Mk 15 Mod 0. A. Front view. B. Left rear view.

tails on loading and other operational procedures, see the appropriate OP):

1. Reinsert the safety pins as soon as use of the projector is no longer imminent.
2. Keep the safety plug and the firing key out of their receptacles on the firing panel at all times except when actually firing or testing electrical circuits.

3. While charges are on the spigots, keep all personnel behind the line of the blast shield when either the safety plug or the firing key is inserted into its firing receptacle.
4. Remove charges from the spigots before testing any of the electrical circuits (except when making the routine circuit test prior to firing).
5. In case of misfires or hangfires, keep all personnel behind the line of the blast shield for at least 10 minutes after the last attempt to fire, regardless of whether or not the safety plug and firing key have been disconnected.
6. Keep the cradle locking device in the locked position at all times except when actually using or greasing the projector.
7. Do not tilt cradles unless half of the spigots on EACH cradle are loaded.
8. Never tilt cradles while anyone is inside the base frame.
9. When loading, lower charges on the spigot gently and make sure that each is seated; give each charge a 360° turn after it is in place.
10. NEVER leave the projector loaded while the vessel is in port, unless you are ordered to do so by the captain.
11. Turn over all defective ammunition to a bomb disposal officer, if one is available.
12. Never tamper with the fuze.
13. Never attempt to remove an armed or partially armed fuze from the charge. A fuze in such condition, and its charge, should be disposed of as indicated in OP 1017.
14. Inspect daily the ammunition on the spigots and in the ready service locker to determine that the fuzes have not become armed or partially armed and that the safety pins are properly assembled in the fuzes.
15. Never do any overhaul work on the projector charge without first removing the fuze.
16. Keep the switch panel and safety plug dry at all times.
17. Exercise extreme care at all times when handling or assembling the ammunition.

DEPTH CHARGE LAUNCHERS AND PROJECTORS

As you already know, depth charges are started on the way toward their submerged targets either by being rolled off a LAUNCHING TRACK at the ship's stern or by being propelled over the ship's side by a special type of gun called a PROJECTOR. We shall take up depth charge launchers and projectors in this section; it is assumed that you have already studied the depth charges themselves in chapters 6 and 7.

Description and Operation of Depth Charge Launching Tracks

The launching track or release gear most used by the Navy is the Mk 3. It consists of a track, a mechanical release linkage, and a hydraulic control system with one control at the track and piping to connect it with another at the bridge.

Release tracks generally are installed in pairs at the stern. The port and starboard tracks are identical, except that controls for both are arranged so as to be inboard. Each track is a relatively simple structural steel frame bolted to the deck. (Fig. 8-21.)

The charges roll between the upper and lower rails, which incline toward the stern. Near the after end, as you can see, is the RELEASE TRAP, in which are two sets of DETENTS or pawls attached to cross shafts. When the operating lever is moved to RELEASE position, the after detents rotate downward. This allows the aftermost depth charge to roll overboard. At the same time the forward detents (not visible in fig. 8-21) rotate upward to prevent the next charge from escaping.

When the control lever is returned to SECURE position, the position of the detents reverses, and a new charge rolls into the trap until it is stopped by the after detents.

Attached to the upper rails are three shafts, each carrying two loosely swinging pawls. They prevent the charges in the release trap from rolling forward as the ship pitches. The forward pawl shaft carries two upper detents (not visible in fig. 8-21) to relieve the lower detents of the weight

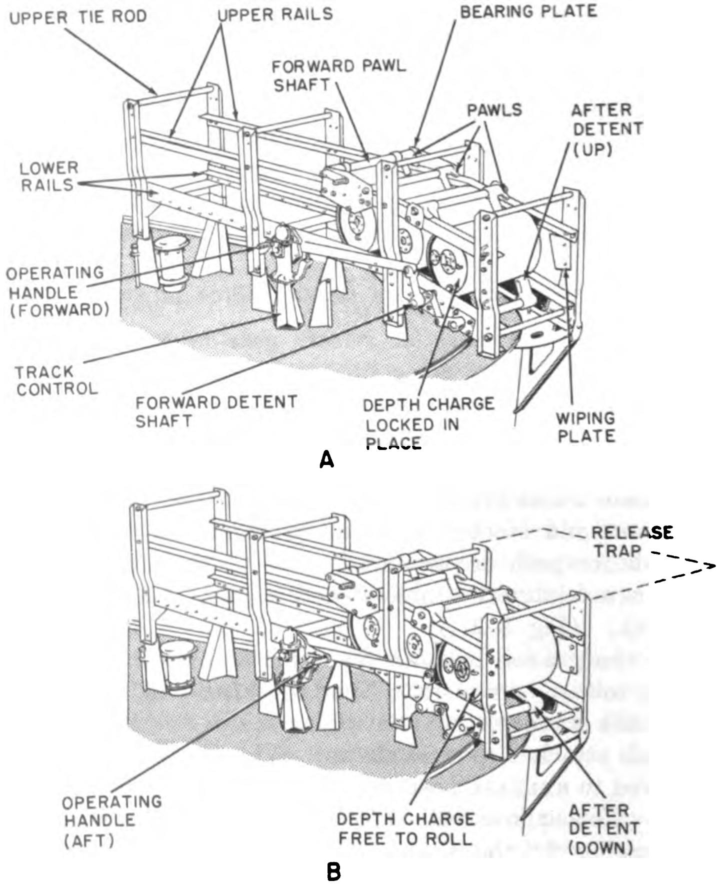


Figure 8–21.—Depth charge release track (Mk 3 gear). A. Secure position. B. Release position.

of the charges carried in the storage portion of the track.

On each of the after end posts is a WIPING PLATE. One wipes off the knobbed cover of the depth charge pistol inlet; the other removes the knobbed safety fork on the depth charge booster extender.

Depth charges are loaded into racks by means of a davit (if available) or by skids or parbuckles. In loading, charges should be EASED DOWN against the after detents or preceding charges, and not allowed to roll freely. Pistol ends of the charges are usually placed inboard for convenience in making depth settings. After loading, substitute knobbed safety covers and forks for plain ones.

In wartime, and when dropping charges for record in peacetime, the aftermost charge is carried against the after detents, ready for instant release. Succeeding charges should contact each other. For peacetime cruising, the aftermost charge is secured, by means of lashings or wedges, just forward of the detents. This relieves the detents of the load and allows testing of the gear without releasing a charge. The forward charge should be secured to prevent forward motion caused by the pitching of the ship.

SAFETY NOTE. Crewmen may yield to the temptation to drape clothing and other personal gear on the tracks. This is dangerous practice. See that the tracks are ALWAYS kept clear.

Normally the release of depth charges is controlled through a hydraulic system (fig. 8–22) from the bridge rather than the track. The hydraulic fluid is made up of glycerine, denatured alcohol, and water. There are two independent systems, one for each track. Each system includes a track control and a bridge control connected by piping. A surge tank, common to both systems, is located close to the bridge. It must always be at least half full.

The bridge and track units of the hydraulic control system each contain a pair of hydraulic rams, each with a rack engaging a pinion gear. As the operating lever on the bridge is thrown to the right or left, one ram moves up and one down. Fluid movement forces the rams at the track control to rotate the operating shaft in the corresponding direction.

Here's the most important point to remember in operating the release gear, either from the bridge or at the track—MOVE THE LEVER SMARTLY AND WITH ONE CONTINUOUS MOTION. If you work the lever too slowly or stop the motion near midstroke, the second depth charge in the release trap

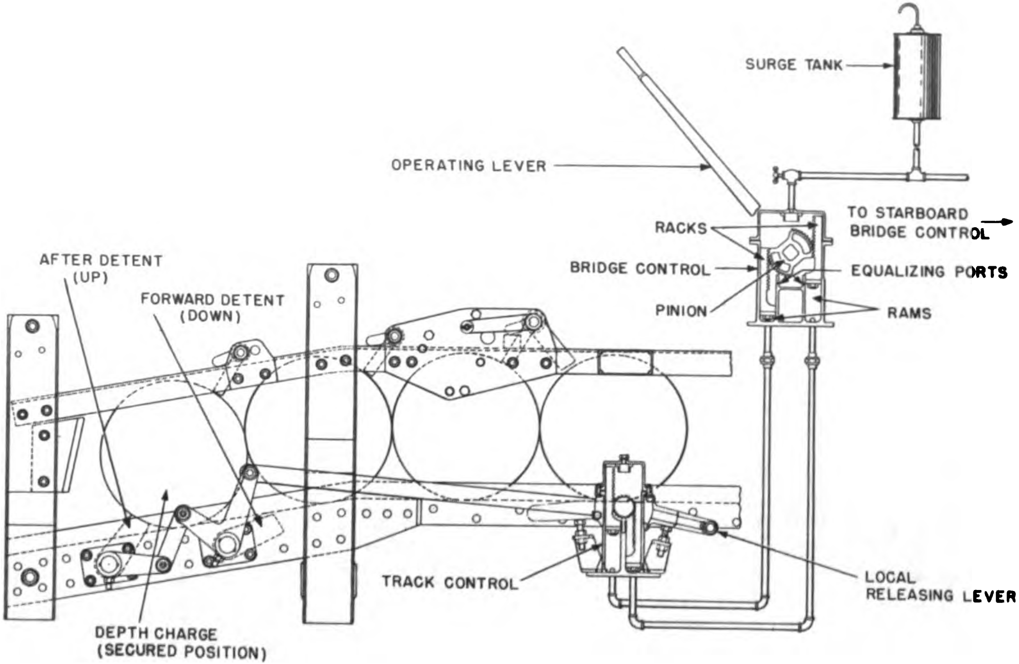


Figure 9-22.—Depth charge release gear: Hydraulic system.

may ride over the forward detents and follow the aftermost charge overboard. Other charges in the track also will follow, unless the upper detents are set to hold them.

When the release track is to operate in local control, be sure that the bridge control lever is locked in position by its toggle pin, and that the track control lever is disconnected from the hydraulic mechanism. Both levers should always be at SECURE when not in use.

Maintenance of Depth Charge Launching Tracks

At least once a week—oftener during cold weather—operate the system through several cycles, both by local and remote control. Make sure that depth charges are secured off the detents during this test.

Check for loss of liquid at least once a week and replenish as necessary. Check pipe fittings, packings, and plugs for leaks.

Check the position of the safety fork wiping plates. The inboard face of the wiping edge should be one-sixteenth inch to one-eighth inch outside a vertical line extending upward from the inside face of the plate forming the guide of the lower rail. If the wiping plates become bent inward, they may foul the case, preventing release. If bent outward, they may not engage the knobs of the safety cap or fork.

Keep track control limit stops tight and in adjustment.

Keep all bearings free of paint and well lubricated, and all bolts tight. Keep all nonworking parts painted.

Description and Operation of Depth Charge Projectors

The depth charge projector now used is the Mk 6, a single-barrel piece called a K-gun, which supersedes the double-barrel Mk 1 (Y-gun). Although it fires one depth charge at a time instead of two, the K-gun actually can launch more charges in the same period than the old Y-gun, because the newer weapon has a faster breech mechanism and can be reloaded in about one-fourth the time required for the older projector.

At least two K-guns are installed on most ships carrying depth charges, each firing on one side. Large destroyers have four or more. Projectors may be fired either electrically from the bridge or by percussion at the projector.

The projector is permanently secured to the ship and cannot be trained or elevated. Its range, however, may be regulated between 50 and 150 yards, depending on what type of depth charge is launched and how much powder is in the impulse charge.

Cartridges containing 14 ounces of spherohexagonal black powder are called No. 1; 20 ounces, No. 2; and 28 ounces, No. 3. Plainly, the larger the impulse charge, the greater the range. Exact ranges are tabulated in a table in chapter 6.

Principal parts of the Mk 6 Mod 1 projector (shown loaded in fig. 8–23, *A*) are the PROJECTOR BODY (including the smooth-bore BARREL and the spherical EXPANSION CHAMBER) and the BREECH MECHANISM. A protective BREECH COVER is chained to the projector pedestal; it should always cover the breech except when the projector is being fired or serviced.

Here is how the projector works:

The depth charge is chained to a T-shaped ARBOR (figure 8–23, *B*) whose stem fits into the projector barrel. An impulse cartridge in the projector chamber is fired; the expanding gases force the arbor and depth charge out of the barrel. As they shoot out, the arbor is automatically freed from the depth charge and falls into the water some 15 to 20 yards short of the depth charge. Separation of arbor and charge after firing is important; if the two remain attached, the depth charge trajectory in the water will be erratic and, with influence-type charges, the explosion will be premature.

The projector barrel is a smooth-bore steel tube 24 inches long with 6-inch inside diameter. Two sea lashing eyes welded to the barrel are used to tie the depth charge and arbor to the projector so that heavy seas cannot wash them overboard. The release link of the arbor chain is attached

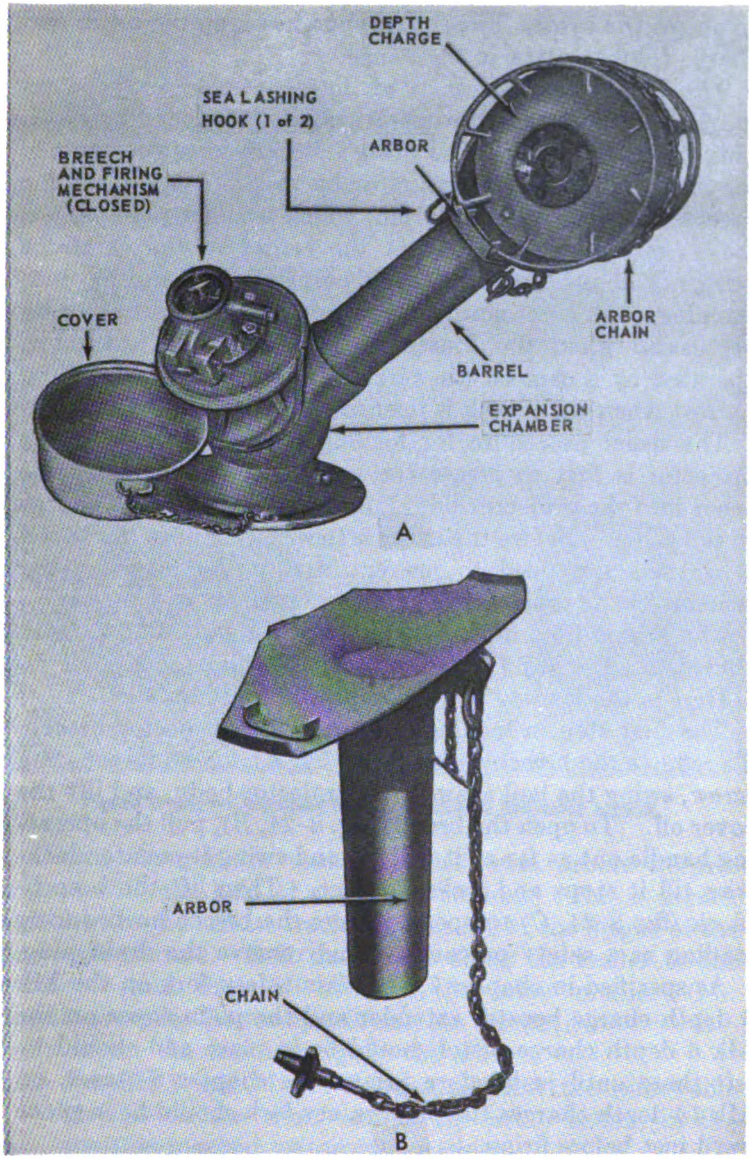


Figure 8–23.—Depth charge projector Mk 6 loaded with Mk 9 depth charge.

to one of the eyes. Two muzzle notches keep the arbor and charge from rotating in the barrel.

The breech mechanism is an interrupted-screw type requiring 90° rotation of the operating handle to lock the breech plug open or closed. The firing mechanism is constructed for firing either by percussion or by electricity. When the breech is opened, the firing pin, which is slightly off center, moves one-quarter inch from the center of the cartridge primer, and an arm retracts the point of the firing pin into the plug, to prevent accidental firing either electrically or by percussion when the breech is unlocked. The extractor, operated by a cam on the carrier, raises the cartridge from its seat when the breech is opened.

The usual procedure for loading a depth charge in the projector is first to grease the arbor stem, then insert the arbor into the projector barrel, and finally attach the charge to the arbor. Before the arbor is inserted, be sure the barrel is cleaned and oiled to prevent rust if the loaded arbor remains in the projector for a long period.

The arbors used at present with Mk 9 and Mk 14 depth charges are the Mk 7 Mod 3 (fig. 8–25) and Mod 4.

Here is the loading and firing procedure in detail:

The first step in loading is to open the projector breech. To remove the breech cover (fig. 8–24, *A*), loosen its securing screw, swing the bail against the projector body, and lift the cover off. To open the breech (fig. 8–24, *B*), pull the operating handle out as far as it will go, and swing it counterclockwise till it stops and locks in place. Then lift the breechblock (fig. 8–24, *C*) to open. Leave the breech open during loading as a safety precaution, and remove the drain plug.

As specified in chapter 7, the plain safety fork on the Mk 6 depth charge booster extender and the plain cover on the Mk 6 depth charge pistol should be in place and should be left there until just before firing. As chapter 8 states, on Mk 14 depth charges the plain safety fork should be in place until just before firing.

The safety latch on the projector should be at SAFE until you are ready to fire.

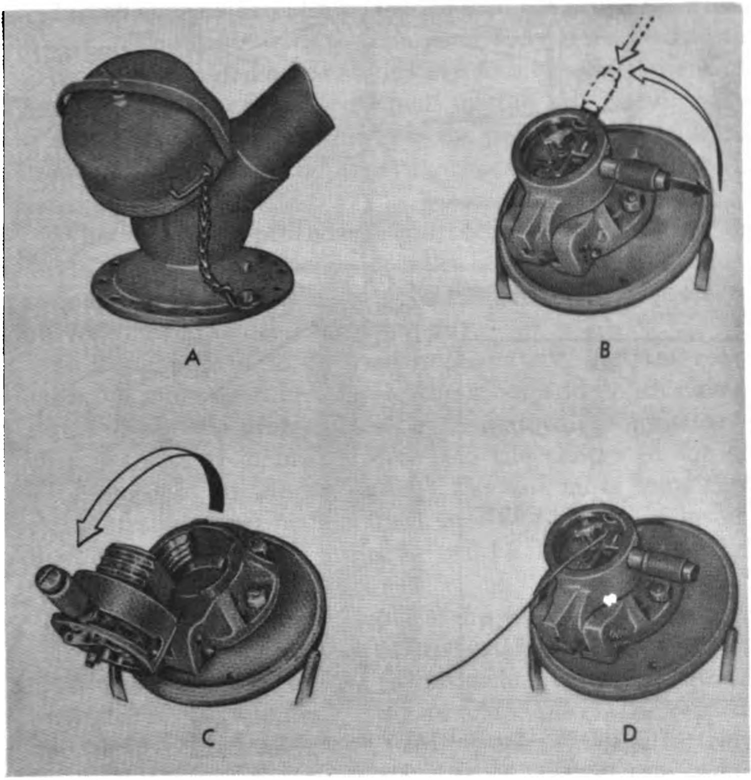


Figure 8-24.—Operating the depth charge projector breech.

Depth charges are usually loaded onto arbors in projectors with the help of a ROLLER LOADER. This is a rack attached to the release track; its rails are at the height of the projector muzzle. Roll the charge along the loader to the projector and then lift it onto the arbor cradle. (For details on roller loader operations, see OP 831.)

To secure the depth charge in the arbor:

1. For Mk 9 and Mk 14 charges, see that the removable stop is on the short end of the arbor saddle in the position marked WEIGHTED CHARGES.
2. Place the charge on the arbor with the nose support ring against the stop. (Fig. 8–25.)

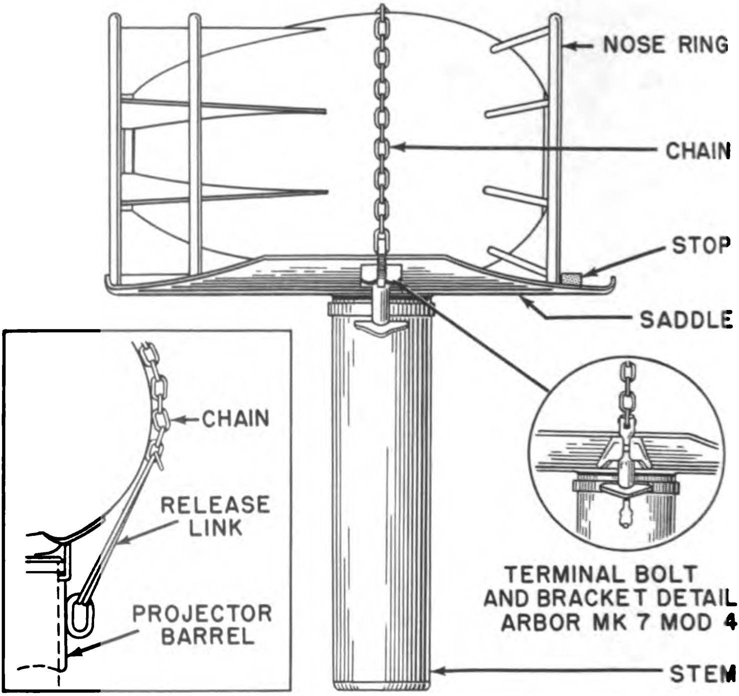


Figure 8–25.—Securing Mk 9 depth charge to Mk 7 arbor.

3. Place the chain over the charge and insert the terminal bolt in the bracket. Take up the chain by tightening the adjusting nut.
4. On Mk 9 charges, install the pistol and booster extender (if not already installed).
5. Check the Mk 9 depth charge when loaded to see that the spring clip of the plain safety fork is on the booster extender spindle. Attach a short lanyard to the fork. Adjust the fork and spring clip so that the fork can be unshipped by a direct pull on the lanyard toward the projector breech. (For details on this and step 4 above, see chapter 6.) With Mk 14 charges, attach a short lanyard to the plain safety fork on the pistol. (For details, see chapter 7.)

Depth charges can also be loaded into the projector with a DAVIT. You begin with the charge already assembled to the arbor. The loaded arbor stands in a fixture called a CANDLESTICK. The procedure is to pick up the arbor and charge with the davit, and swing it over the projector, lowering the stem into the barrel and applying grease to the stem at the same time.

Whether the depth charge and arbor are loaded by the davit or by the more common roller loader method, the next step after loading is to secure the arbor chain to the projector barrel and tighten the adjusting nut.

If the charge is to be fired immediately, and the sea is calm, no more need be done to the arbor and depth charge. But to keep the projector ready for immediate action over long periods, or in heavy seas, lash the charge to the sea lashing hooks on the projector. Use not more than three turns of spun yarn or five turns of Navy marlin in lashing the charge, so that the projector can be fired safely without first unlashing the charge.

Next, if time permits, replace the projector drain plug. (However, the projector can be fired safely with the plug out.)

All that remains is to load the propellent cartridge, and the projector is ready to fire. To load, place the cartridge in the opened breech chamber and gently push until the cartridge flange rests upon the raised extractor. Then, close and lock the breech. Last, connect the electric cable (for the preferred method, electrical fire) or tie a lanyard to the firing lever, as in figure 8–24, *D* (for percussion fire).

The electrical firing panel is located on the bridge. The projector is fired by 15 to 20 volts AC or 6 to 21 volts DC.

The percussion firing procedure is as follows:

1. Retract the firing lever bolt.
2. Take a position about 8 feet behind and facing the breech. Grasp the lanyard firmly but without strain.
3. At the command FIRE, pull the firing lever quickly and steadily all the way back.

Always keep the breech mechanism set at SAFE until ready to fire.

To recock after firing, push downward on the firing lever until the sear toggle latches under the firing pin knob.

After firing (either electrical or percussion), open the breech and remove the empty cartridge by hand.

Depth Charge Projector Maintenance

The maintenance of projectors consists mainly of cleaning, lubricating, and slushing to keep water off bearing surfaces and prevent rust of working parts, and keeping electrical circuits in operating condition.

Between periods of firing, use every precaution to keep water from entering the gun. Unless loaded with an arbor, keep the muzzle closed with a wooden tompion and covered with a muzzle bag. Don't let water, oil, or sediment collect in the expansion chamber. Leave the vent plug out if rain or heavy seas cause water seepage into the projector. (Firing with the vent plug out, in emergency, will reduce the range only about 2 or 3 percent.) Dry and oil the breech mechanism and secure the breech cover tightly after use.

Inspect the breech mechanism frequently for any signs of rust. Remove any rust found, and recoat all parts with oil. It will be necessary to remove the breech mechanism from time to time and disassemble the parts in order to inspect and clean each part thoroughly. (For disassembly procedure, see OP 831.)

Slush the projector barrel and cartridge chamber periodically with light oil to prevent rust or corrosion. Grease the bearings often, so that smooth operation is assured at all times.

Formation of ice in the projector can be as detrimental to the projector's action as rust or corrosion. Keep it as ice-free as possible.

The important electrical maintenance procedure is testing the firing circuit. This must be done regularly, as required by the gunnery officer or ASW officer, and when inspecting the projector after recent firing.

ALWAYS test with the breech OPEN to be sure that the firing pin is not in contact with a live primer or that the firing pin is not grounded to the breechblock. No one may make alterations to the firing pin or breechblock for the purpose of making it possible to test the circuit with the breech closed on an empty chamber.

The approved testing procedure is:

1. Open the breech, making sure the firing pin has retracted. If a cartridge is in the chamber, remove it. Also remove the tompion or arbor in the barrel.
2. Check to see that the firing key is open at the control station or that the firing circuit is open at the projector.
3. Insert a cartridge case with live primer (but WITHOUT propellant) into the chamber.
4. Be sure nobody is in front of the barrel. Close the breech.
5. Set the mechanism on READY and close the firing circuit. You should be rewarded with a bang.

To test the breech for percussion firing, go through steps 1 through 4 above, then attach the lanyard, retract the firing bolt, and pull the lanyard smartly as far as it will go.

Safety Precautions To Observe in Projecting Depth Charges

1. See that the breech is OPEN before loading an arbor and depth charge.
2. Until the breech is closed and locked—
    a. The firing key or switch must be open at the control station; or
    b. The firing cable at the firing pin must be disconnected.
3. Do NOT keep a cartridge in the breech chamber except when in a danger zone. It can be loaded in 10 seconds.
4. Keep the charge and arbor lashed to the sea lashing hooks unless immediate firing is contemplated.
5. Do not fire a projector if water or oil has collected in the expansion chamber. Remove the drain plug if there is any doubt, and fire with the vent left open.

6. To prevent accidental depth charge explosions, keep Mk 6 depth charge pistols set on SAFE until the depth setting has been ordered in preparation for firing. And be sure that until you are about to fire the plain safety fork's spring clip engages the extender spindle.
7. Do not snap a firing pin unnecessarily, especially into an empty chamber.
8. Be careful not to strike the firing pin while a cartridge is in the chamber. A blow may explode the cartridge.
9. If a misfire occurs, wait 10 minutes before opening the breech. Be sure to stand to the side of the breech to open it.
10. See that the breech is unloaded before performing any work on the projector.
11. Keep the safety latch in its SAFE position until ready to fire.
12. Do NOT tie a depth charge safety fork to the projector or to any part of the ship's structure. Remove safety forks and safety covers by hand.

CONCLUSION

This chapter has described the current types of rocket armament, depth charge launchers and projectors, and other A/S projectors and ammunition in general service on ships of the U. S. Navy. Because of space limitations, it has not been possible to go into maintenance, adjustment, upkeep, and repair of these equipments; and many operational details likewise have been omitted. If you are assigned to ships with such equipment aboard, you should make it your business to study it, using the OP's and other technical sources available.

QUIZ

In each of the following, select the BEST answer.

1. The caliber of a rocket (complete round) is determined by the
   a. diameter of the motor
   b. diameter of the head
   c. diameter of the tail shroud
   d. length of the round over-all

2. The extension of the rocket nozzle, leading outward from the nozzle aperture, is tapered in order to
    - a. decrease turbulence
    - b. decrease air resistance
    - c. increase flow
    - d. increase thrust
3. The purpose of the inhibitor in a rocket is to
    - a. decrease turbulence
    - b. increase maximum burning area
    - c. increase gas production
    - d. decrease initial burning rate
4. Which of the following parts of a rocket assembly is NOT necessary in spin-stabilized rockets?
    - a. Motor
    - b. Head
    - c. Fins
    - d. Inhibitors
5. The purpose of the safety clip on the 4.5-inch rocket is to
    - a. lock the fuze vanes
    - b. clip the nozzle closure disc to the after end
    - c. short-circuit the rocket's firing leads
    - d. connect the shrouds to the ignition squib
6. The 4.5-inch rocket fuze Mk 137 arms fully when the
    - a. shutter lines the detonator up with the booster and the firing pins
    - b. rotation of the vane disengages the shutter from the setback spring
    - c. force of impact drives the firing pin into the detonator
    - d. setback block is held forward by the setback spring
7. The Mk 100 fuze for spin-stabilized rockets is armed by
    - a. setback
    - b. rotation of the rocket during flight
    - c. rotation of vanes in the air
    - d. hydrostatic pressure after it strikes the water
8. The fuze must NOT be assembled to the Mk 8 head for the 5-inch SS rocket on shipboard because
    - a. it is unsafe to do so until time for launching
    - b. the Mk 8 head is inert and requires no fuze
    - c. the Mk 8 head is shipped with the fuze already in place
    - d. the adapter must be screwed into the Mk 8 head before attempting to assemble the fuze to it
9. The purpose of the intervalometer on the Mk 102 rocket launcher is to
    - a. introduce a short delay between the firing of the two rockets
    - b. ensure that both rockets are fired simultaneously
    - c. prevent firing of rockets into own ship's structure
    - d. limit the interval between firing of salvos

10. The main advantage of the Mk 20 rocket launcher with respect to small vessels is that
   a. its rocket burster charges detonate only on a direct hit
   b. its rockets are spin-stabilized
   c. it can fire either ahead of or behind the firing ship
   d. it produces practically no deck thrust when fired

11. The 12.75-inch rocket pistol is detonated by
   a. rotation of vanes on its nose
   b. magnetic effects of its target
   c. hydrostatic pressure
   d. setback

12. The Mk 108 rocket launcher's loading position is at
   a. 10° elevation
   b. 0° elevation
   c. 90° elevation
   d. elevation transmitted from underwater plot

13. The best time to remove short-circuiting devices from rocket motors is when the rockets are
   a. removed from the magazine
   b. assembled to their heads
   c. fuzed
   d. loaded into their launchers

14. The Mk 158 fuze for the 7.2-inch projector charge normally arms fully by
   a. impact with the water
   b. rotation of a vane in the water
   c. hydrostatic pressure
   d. rotation of a vane in air

15. The proper way to move the operating lever of the depth charge launching track control is to
   a. stop briefly at midstroke to permit the ram to catch up
   b. accelerate the movement slowly to avoid shock to the mechanism
   c. move the lever in one brisk continuous motion to prevent dropping two charges on the same stroke
   d. swing the lever all the way over and then back to mid-position to prevent the detents from jamming the charges

16. During loading of a depth charge projector, which of the following should be removed from the projector?
   a. Arbor
   b. Drain plug
   c. Breechblock
   d. Firing mechanism

CHAPTER 9

MINES AND AIRCRAFT BOMBS

INTRODUCTION

The two types of weapon discussed in this chapter are not as likely to be your direct responsibility as will be the others that you have studied in this training course and elsewhere. But, though you need not know as much about bombs and mines as you are expected to know about, say, gun ammunition and depth charges, you may find yourself in a billet—aboard an aircraft carrier or minelayer, for example—in which you will work with bomb and mine experts. Moreover, it is always a good idea to know a little more than the minimum your present job requires. So you will find it advisable to learn something about bombs and mines.

In this chapter, we shall first take up aircraft bombs.

WHAT'S A BOMB?

Fundamentally, an aircraft bomb is a steel case containing an explosive or chemical and is fitted with a fuze or fuzes to explode or scatter the charge at the target. Each type is designed primarily for a specific purpose.

The components of a bomb differ in detail, depending on the particular type and model; but, in general, a bomb consists of the following principal parts:

1. The bomb CASE or body, containing explosive, chemical, or incendiary material.
2. The fuze or fuzes.
3. The fin or tail assembly.
4. The arming wire assembly.

The GENERAL-PURPOSE bomb shown in figure 9-1 is equipped with two fuzes, one at each end. The fuzes screw into recesses or FUZE POCKETS at the nose and tail of the bomb. Either fuze alone can do the work, but two are common.

Farther aft you see the FIN OR TAIL ASSEMBLY. This tail, a comparatively light sheet metal affair, is what makes it possible to aim the bomb. Because of it, the bomb falls in a smooth predictable trajectory instead of tumbling erratically through the air. If the tail is dented or bent, the bomb may fall in a cockeyed path and land "off-target." This is important to remember when you are handling bombs or supervising their handling.

The tail is attached to the bomb by the FIN LOCK NUT or TAIL LOCK NUT screwed to the rear of the bomb.

Running along the top of the bomb body you see the ARMING WIRES. These wires are used to foul the little propellers or ARMING VANES of the fuzes so that they will not rotate and thus arm the fuzes before the bomb is dropped from the airplane.

The BOMB BODY is a cylindrical steel case curved to a streamlined shape at the nose and tapering slightly in the rear. The case has a threaded opening in the nose to receive a fuze. At the rear is a large opening through which molten explosive is poured at the loading plant. After loading, this opening is closed by a BASE PLUG. The base plug has a threaded projection designed to receive the tail locking nut. In the center of the base plug is a threaded hole into which a tube—called the ADAPTER BOOSTER or FUZE SEAT LINER—is screwed. This tube is threaded on the inside so that the tail fuze can be screwed into it.

On the outside surface of the bomb body are lugs for hoisting and for suspending the bomb on the plane. Some bombs have drilled and tapped holes for installing the lugs.

TYPES OF BOMBS

EXPLOSIVE BOMBS are mainly intended for the destruction or demolition of material targets. The destructive effect

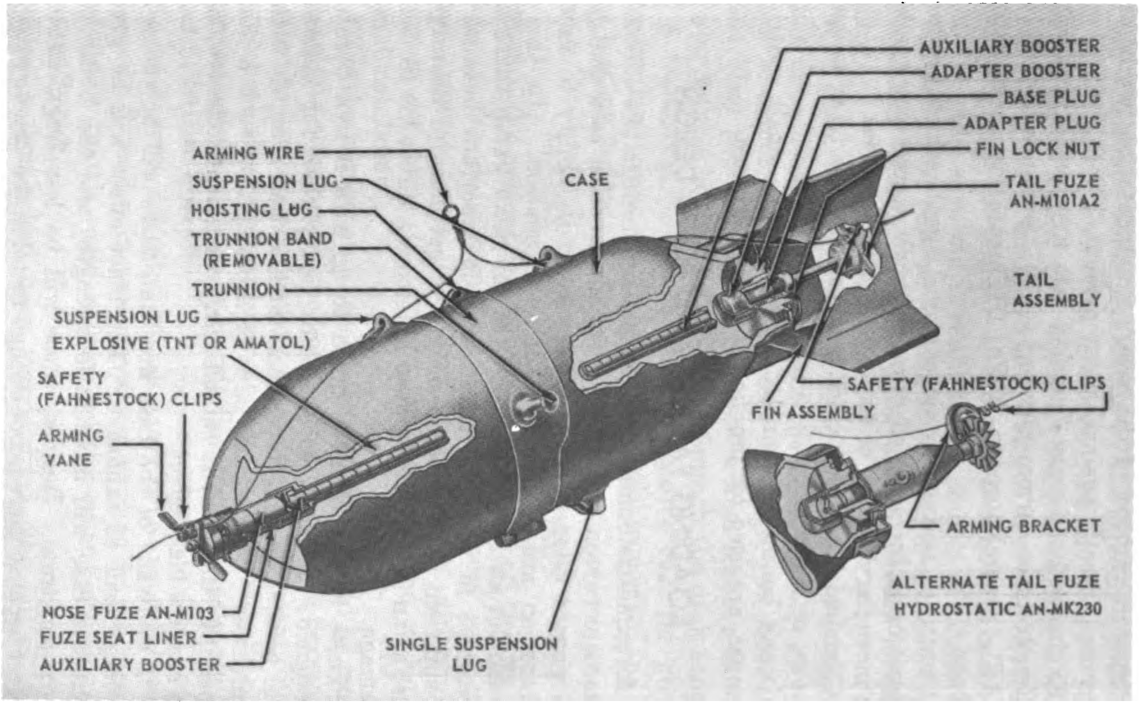


Figure 9–1.—A 500-pound general-purpose (GP) bomb.

may be produced by the BLAST EFFECT of the detonation or by FRAGMENTATION of the case. Fragmentation bombs are also used directly against enemy personnel.

Explosive bombs are classified into five main types with different uses—armor-piercing (AP), semi-armor-piercing (SAP), general-purpose (GP), fragmentation, and depth bombs.

CHEMICAL BOMBS contain chemical agents which produce a toxic or an irritating effect on the body, a screening smoke, an incendiary action, or any combination of these.

Chemical bombs are classified, according to filler, as gas, smoke, or incendiary.

INERT bombs, or miniature bombs with small spotting charges, are used for practice and drill purposes.

LOADING FACTOR AND BOMB DESIGN

An explosive bomb can do its damage through two effects—FRAGMENTATION and BLAST. Its effectiveness as a destructive agent often depends, however, on its ability to PENETRATE an armored target before detonation. (In this it resembles an AP projectile.) On the other hand, there are instances in which penetration is unimportant because it is sufficient for the bomb merely to get close to its target, just as an AA projectile need not score a direct hit to cause damage.

These factors all have much to do with how a bomb is designed. A bomb with a thick heavy case, for instance, will be able to penetrate much farther than a bomb with a thin case. But because most of the weight of such a bomb goes into the case, it cannot carry as much explosive, and so has less blast effect.

If the walls of the case are thin, there will be room for a large load of explosive. The blast effect will be great. But the case will have little strength, and the bomb will NOT penetrate. Besides, there will be less fragmentation effect because there is not enough metal in the case to provide many fragments.

From this, it is obvious that, if you know what percentage of the weight of a bomb is taken up by the explosive, you can tell quite a bit about its characteristics and uses. This percentage is called the LOADING FACTOR of the bomb. More exactly, it is the RATIO of the weight of explosive to the total weight of the bomb. If the total weight of a bomb is 1,000 pounds, say, and it contains 500 pounds of explosive, it will have a 50 percent loading factor. If it contains only 150 pounds of explosive, it will have a 15 percent loading factor.

Well then, what is the best loading factor for a bomb? That depends on what you want the bomb to do. If you want to demolish a row of masonry buildings, you want the most blast possible—hence you need a high loading factor. If you want a bomb which will get through the deck armor of a battleship, you must have a massive case for great penetration power, and that means less explosive and a low loading factor.

MARKS AND MODS FOR BOMBS

Before the Second World War, the Army and the Navy each developed its own bombs. Both Services used the same general types, but there were marked differences between an Army GP bomb, for instance, and a Navy demolition bomb.

After the war began, it was decided that it would be more efficient to standardize the bombs used by the two Services. A standardization committee was set up with representatives from the United States Army and Navy, and with British representatives so that the standardized equipment could be used in British aircraft.

In each type, a United States Army or Navy bomb was selected. Usually, it was necessary to modify its design slightly so that it could be used by the other Services and by the British.

When a bomb had been standardized, the letters AN (Army-Navy) were placed before its designation. Thus, the AN–M30 is a 100-pound GP bomb standardized from the

Army M30 bomb. The AN–Mk 1 bomb is a 1,600-pound AP bomb standardized from the Navy Mk 1 bomb. In general, standardized depth bombs and armor-piercing bombs are modifications of Navy originals. Most other standardized bombs are modifications of Army originals.

The same standardization program has been followed on fuzes and on some other types of airborne ordnance equipment. Standardized equipment is designated in the same manner as bombs.

HANDLES FOR BOMBS

A bomb is a completely effective weapon as just a simple steel box full of explosives, plus a fuze to set it off. But before bombs can be dropped on the enemy, they have to be picked up, moved around, suspended under the wings of planes, slung into bomb bays, and fastened under dive bombers. So they need handles. This may seem both trivial and obvious, but it is actually a practical and important problem. Bomb handling is something you may have a great deal to do with if you are aboard a carrier.

The aircraft pilot or bombardier must have his bomb load under control at all times. He must be able to drop his bombs armed (with fuzes ready to function), one at a time or in salvo; he must be able to select the type of arming desired when a choice is possible; and he must be able to jettison his bombs unarmed (safe) if necessary when his plane is in trouble. Bomb suspension and release gear is designed to deal with all of these requirements.

Bombs may be suspended either in RACKS or in SHACKLES. Racks are structurally part of the airplane; shackles are themselves suspended from the aircraft structure, and can swing out of the way to permit the release of bombs carried above them. The bombs are hooked to the racks or shackles by U-shaped steel loops called SUSPENSION LUGS. Suspension lugs are often welded to the body of the bomb, but on some depth and AP bombs they are bolted or screwed to the bomb body.

Bombs are usually suspended from two lugs 14 inches apart, except that 2,000-pound bombs are suspended from lugs 30 inches apart. The British method of suspension involves the use of only one lug, and therefore a SINGLE LUG is provided, opposite the double lugs, on AN-standard bombs. You can see this single lug in figure 9–1.

Large bombs are hoisted up under the wings or into the bomb bay of an airplane with a cable and winch. Because the cable must be fastened to the bomb, but the suspension lugs cannot be used for this purpose, HOISTING LUGS are provided. On Navy bombs, the hoisting lugs are welded or screwed to the bomb case; but on AN-standard bombs of Army origin, the hoisting lugs are fastened to metal bands which can be placed around the bomb when needed and tightened in place with bolts. Hoisting lugs are shown in figures 9–4 and 9–5.

In a DIVE BOMBING operation, the plane is in a steep dive at the moment the bomb is released. If the airplane simply let go of the bomb, the bomb would fall forward almost in the line of flight of the airplane and might crash into the propeller. Therefore, the bomb must be pushed away from the airplane as it is released. This is done by DISPLACEMENT GEAR which consists mainly of a pair of arms that swings out and away from the airplane fuselage to push the bomb out of the line of flight, so that it will clear the propeller circle when dropped.

The point about this that is important to you is that the displacement gear engages the bomb by means of a pair of TRUNNIONS on either side of the bomb case. On armor-piercing bombs and some depth bombs, they are screwed into tapped holes in the case; but, on most other bombs, they are welded to BANDS which are placed around the bomb and tightened with bolts. Frequently, HOISTING-TRUNNION BANDS are used; they carry both a hoisting lug and a pair of trunnions. You can see this arrangement in figure 9–4.

EXPLOSIVE TRAIN

As with gun projectiles, bomb bursting charges are composed of relatively insensitive explosives which do not normally detonate upon mechanical impact. This simplifies bomb handling and makes possible the passage of the AP or SAP type of bomb through armor before exploding, but (again, as with gun projectiles) makes necessary the use of series of explosions inside the bomb to set off the booster. This is the function of the **EXPLOSIVE TRAIN**.

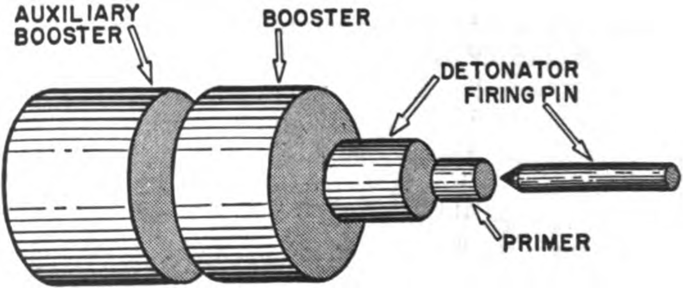


Figure 9-2.—Elements of a bomb's explosive train.

First in the explosive train are the primer and the STRIKER OR FIRING PIN. The pin is driven into the primer to set it off. The primer, in turn, initiates the detonator, which detonates the booster and the auxiliary booster, which finally detonates the main charge.

The explosive constituents of a typical explosive train are as follows:

The PRIMER is composed of a fraction of an ounce of mercury fulminate. This detonates readily when the firing pin strikes it a light blow.

The energy of the primer's explosion is too small to explode the insensitive main charge. But it can set off the next element in the explosive train—another charge of explosive, called the DETONATOR, which contains an explosive (usually lead azide) less sensitive than that in the primer. Because of its lesser sensitivity, the detonator can safely be made much larger than the primer.

In explosive bombs, even the detonator is not sufficient to explode the main charge. It sets off a still larger charge, the BOOSTER, which is generally made of tetryl. In most bombs, the booster's explosion sets off the main charge.

It is obvious that bombs can be stored and handled more safely if the sensitive portions of the train—such as the primer end—are omitted from the bombs until they are ready for use. For this reason several elements of the sensitive end of the train are put into a separate mechanism—the FUZE—which is stowed separately and mounted on the bomb only when it is due to be loaded on the aircraft. (Exceptions to this are small chemical and fragmentation bombs, and some practice bombs, which are shipped with fuzes already assembled.)

BOMB FUZES

Bomb fuzes are classified, according to position, as NOSE, TAIL, and TRANSVERSE (or ATHWARTSHIPS); and, according to function, as DELAY, IMPACT, HYDROSTATIC, and VT (or INFLUENCE).

Delay (or time) fuzes function a predetermined length of time after the arming pin is released; impact fuzes function when the bomb strikes a resistant material; hydrostatic fuzes function by water pressure; and VT or influence fuzes function upon approaching a target.

Principles of Bomb Fuze Functioning

A bomb fuze that is ready to function is ARMED. However, to make them as safe to handle as possible, most bomb fuzes are not armed until AFTER release from the aircraft. The methods of arming bomb fuzes are taken up later in this chapter. In discussing bomb fuze functioning in this article, we shall assume that the fuzes are already armed.

As you noticed in figure 9–2, the explosive train of a bomb starts functioning when the striker or firing pin is driven into the primer. This operating principle applies to all present bomb fuzes except the VT type, which is initiated electrically.

Delay or time fuzes begin to function upon impact, which initiates either a black-powder train (for delay periods up to 15 seconds), or some other type of delay mechanism (for longer delays). A typical long-delay mechanism is one in which impact opens a container of a chemical that after a time dissolves or otherwise releases a safety device which, in turn, permits a spring-loaded firing pin to strike the primer.

Long-delay fuzes of this kind are often supplemented by ANTIWITHDRAWAL fuzes (which arm on impact and go off when some one tries to withdraw them) or ANTIDISTURBANCE fuzes (which also arm on impact, but go off when some one attempts to tamper with the bomb).

In an impact-type NOSE fuze, the firing pin (or an extension of it) protrudes forward and the firing pin is driven home when the bomb strikes a resistant object. In an impact-type TAIL fuze, the firing pin is attached to a heavy plunger that is held away from the primer by a light spring, known as an ANTICREEP SPRING. When the bomb hits anything solid, it slows down suddenly. But the plunger continues to move on downward, compressing the anticreep spring, and thus drives the firing pin into the primer. This is slower action than that of the nose fuze.

Delays of up to 0.1 second may be introduced into impact fuzes to increase their effectiveness under certain conditions, as you will see in the next article of this chapter.

These fuze actions resemble, in general, those of gun projectile fuzes. With the hydrostatic fuze, however, we encounter a different principle of operation—one more closely related to that of the depth charge. In these fuzes, water is admitted into the fuze, where it pushes against a piston. A spring resists displacement of the piston. The greater the depth of water, the greater the pressure against the piston and the farther the piston will move. When the piston has moved a certain distance, it trips a cocked spring-loaded firing pin which strikes the primer and detonates the bomb.

On present hydrostatic fuzes, the depth is set by moving a dial on the outside of the fuze. The most commonly used setting is 25 feet.

Hydrostatic fuzes in present depth bombs are installed in the bomb tail. (Older bombs used to have athwartships fuzes too.) Hydrostatic tail fuzes are armed by a vane.

Lastly, let's consider the VT (influence) fuze. Like those in gun projectiles, VT bomb fuzes function upon approaching material objects. These fuzes are essentially radio transmitting and receiving units. In flight, the fuze broadcasts a continuous radio signal. When this signal is reflected from any object to the armed fuze, it interacts with the transmitted wave to produce ripples or beats. When the beat reaches a predetermined intensity, it trips an electronic switch which permits a current to set off an electric detonator.

There are two types of VT bomb fuzes, the BAR type and the RING type. In both types, the external part of the fuze is cylindrical in shape with a vane at the nose. The ring type has a metal ring around the vane, with a vane stop pin sealed in the ring. The bar type has two metal bars extending radially from the head, and a vane stop arm mounted on a bracket on the side. In both types, the part of the body assembled within the bomb resembles in size and shape the conventional fuze, except for a safety pin clipped around the base extending into the end of the fuze. This pin is removed just before assembling the fuze to the bomb.

When the bomb is dropped, the arming vanes are released as the bomb falls through the air, the vanes rotate, driving a high-speed shaft, a reduction gear train, and a low-speed shaft. Mounted on the high-speed shaft is an electric generator whose output charges a firing condenser and operates the transmitting and receiving unit. The detonator rotor is keyed to the low-speed shaft by a spring-loaded pin. The rotor controls both mechanical and electrical arming. Until arming is complete, it keeps the detonator out of line with the booster lead, and disconnects the detonator from the firing circuit. When the rotor turns to armed position, its spring drives the outer end of the key pin into a recess in the rotor housing while the inner end withdraws from the keyway in the shaft. This action disengages the rotor and permits the high-speed shaft and generator to continue functioning.

When a material object enters the area of influence of the fuze, the reflected wave causes the firing switch to close the circuit of the firing condenser through the electric detonator, thus initiating the explosive train.

Fuze Delays and Functioning Times

Often, even with impact fuzes, delay is desirable in fuze functioning to make the bomb more effective. This is important in bombs designed to penetrate armor, for instance. This DELAYING ACTION is incorporated into many fuzes by putting a DELAY ELEMENT into the firing train, next to the primer. The delay element is usually a pellet of tightly packed black powder which is ignited by the explosion of the primer. It takes a definite time (depending on the fuze, from 0.01 second to 0.1 second) to burn through.

A second primer, the RELAY, next to the delay element, explodes when the delay has burned through to it. The relay sets off the detonator and the remainder of the explosive train.

The amount of delay in the firing of a fuze is its FUNCTIONING TIME. Functioning time can be adjusted in some fuzes, or the delay can be cut out of the explosive train for instantaneous firing.

The primer and detonator currently used in tail fuzes equipped for delay firing are mounted in a separate piece—the PRIMER-DET—screwed into the base of the fuze. The primer-det is made with several different delay times, from zero (instantaneous functioning) to 0.1 second. The delay time is always stamped on the base of the primer-det by a color code. Nondelay primer-dets are unpainted.

Arming of Bomb Fuzes

When a bomb fuze is unarmed (safe), it cannot function. In some fuzes, a pin through the striker keeps it safe; in others, a block of metal under the striker head or a screw securing it to the fuze body performs this function. In DETONATOR-SAFE fuzes, the detonator or primer is out of line with the firing pin when the fuze is unarmed. Some fuzes use a combination of these methods.

In general, nose fuzes are held unarmed by safety blocks which prevent the firing pin from being driven into the primer. Tail fuzes are held unarmed by an arming stem screwed into the inertia-type firing pin.

Bomb fuze arming may be either DIRECT or DELAYED. In direct arming, the fuze becomes armed or ready to function immediately on ejection or removal of the arming pin or safety blocks, or when the arming stem is unscrewed by the rotation of the arming vane. In delayed arming, ejection of the arming pin initiates a powder train or clockwork mechanism which arms the fuze after a set time. Or the arming vane's rotation may be conveyed to the arming stem by a reduction gear train which delays its disengagement.

Bomb fuzes are usually armed by the rotation of ARMING VANES, which are turned by the passage of air as the bomb falls. The function of the ARMING WIRE, when used with vane-armed fuzes, is to prevent the vanes from rotating in the plane's slipstream and arming the bombs before release.

Physically, the arming wire is a length of brass or bronze wire with a flat eyelet at one end. Usually two wires—one for the nose fuze and one for the tail—are attached to the same eyelet. The wires are threaded through the fuzes so that they foul the arming vanes. SAFETY CLIPS (also called FAHNESTOCK CLIPS), slid over the wire next to the fuze, keep the wire from slipping out from between the vanes. The eyelet end of the arming wire is engaged by a RETAINER on the bomb rack or shackle. The retainer's functioning is controlled by the bombardier's selector handle. If the selector handle is set on "Safe" when the bomb is dropped, the retainer releases the arming wire with the bomb, so that the vanes cannot rotate and the fuze remains unarmed. If the handle is set on "Arm," the retainer holds the arming wire firmly; the bomb drops without the wire, the vanes turn freely, and by the time the bomb is safely distant from the aircraft, the fuze is fully armed.

Some bomb racks and shackles have several arming wire hooks on them. Thus it is possible to arm one fuze and not the other. This is called SELECTIVE ARMING.

TYPES OF EXPLOSIVE BOMBS

Let us now take up the various types of explosive bombs.

General-Purpose Bombs

The most common type of bomb, as you would expect from the name, is the GENERAL-PURPOSE or GP bomb, illustrated in figure 9–1. This is a sort of compromise bomb. It has good blast effect, fair penetration, and some fragmentation. It has a loading factor of about 50 percent. Its case is one-fourth to one-half inch thick, depending on the size of the bomb. This gives it enough strength to penetrate several decks of an unarmored ship or several floors of an ordinary building. It does most of its damage by blast.

The explosive filling of GP bombs is either TNT or AMATOL, which is a mixture of TNT and ammonium nitrate. Amatol has just about as much explosive power as straight TNT and is a lot cheaper. It does have one important disadvantage: It tends to absorb moisture from the air. As the chemists say, it is hygroscopic. Therefore, the nose and tail ends of amatol-loaded bombs are filled with TNT. These TNT "surrounds" seal the amatol away from the air.

Because it is used often, the general-purpose bomb is available in a wide range of sizes. The smallest weighs 100 pounds and the largest 2,000 pounds. Its fat silhouette (fig. 9–3) makes it a compact container of explosive rather than an armor penetrator.

Semi-Armor-Piercing Bombs

More heavily armored targets require a thicker-walled body than that of the GP bomb—which is, as has been noted, a compromise—in order to penetrate deck armor. The bomb designed for use against such targets is the SEMI-ARMOR-PIERCING or SAP bomb. This bomb rather resembles the GP but, because of its thicker case, has a smaller amount of explosive and a correspondingly lower loading factor.

Because of its heavier case, the SAP bomb can penetrate 2 to 3.7 inches of armor plate, depending on the height from which it is dropped. This makes it a useful bomb against such targets as aircraft carriers, old heavy cruisers—and even large merchant ships whose many decks might stop a GP bomb before it could get far enough in.

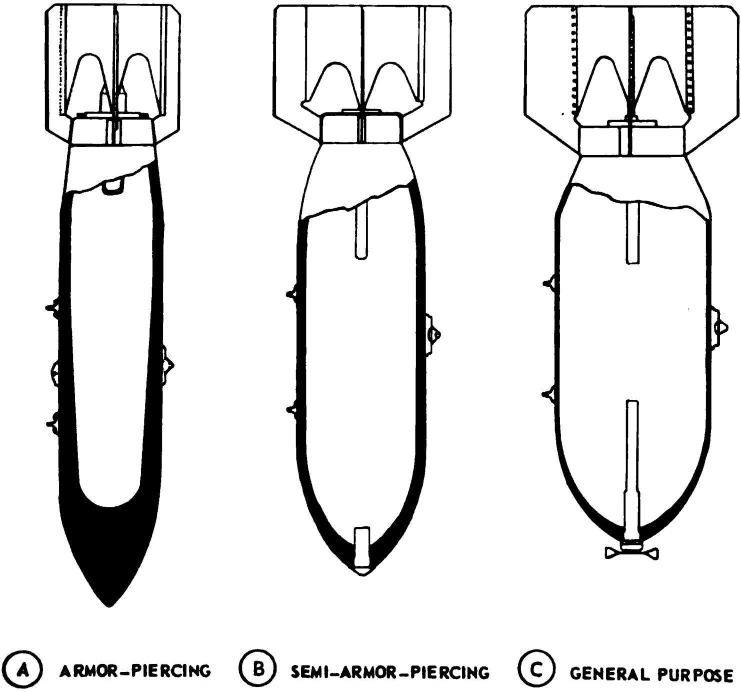


Figure 9–3.—Comparison of three types of explosive bombs.

Because of its thicker case, the SAP bomb contains a smaller quantity of explosive. It has a loading factor of only about 30 percent. It penetrates the target farther than a GP bomb can, but its blast effect is not as great. The SAP bomb gives efficient fragmentation.

The SAP bomb is used by the Navy in two sizes—500 and 1,000 pounds. In appearance, it generally resembles a GP bomb, except that it is slimmer (fig. 9–4). Like the GP bomb, it is loaded with TNT or amatol. It has fuze pockets

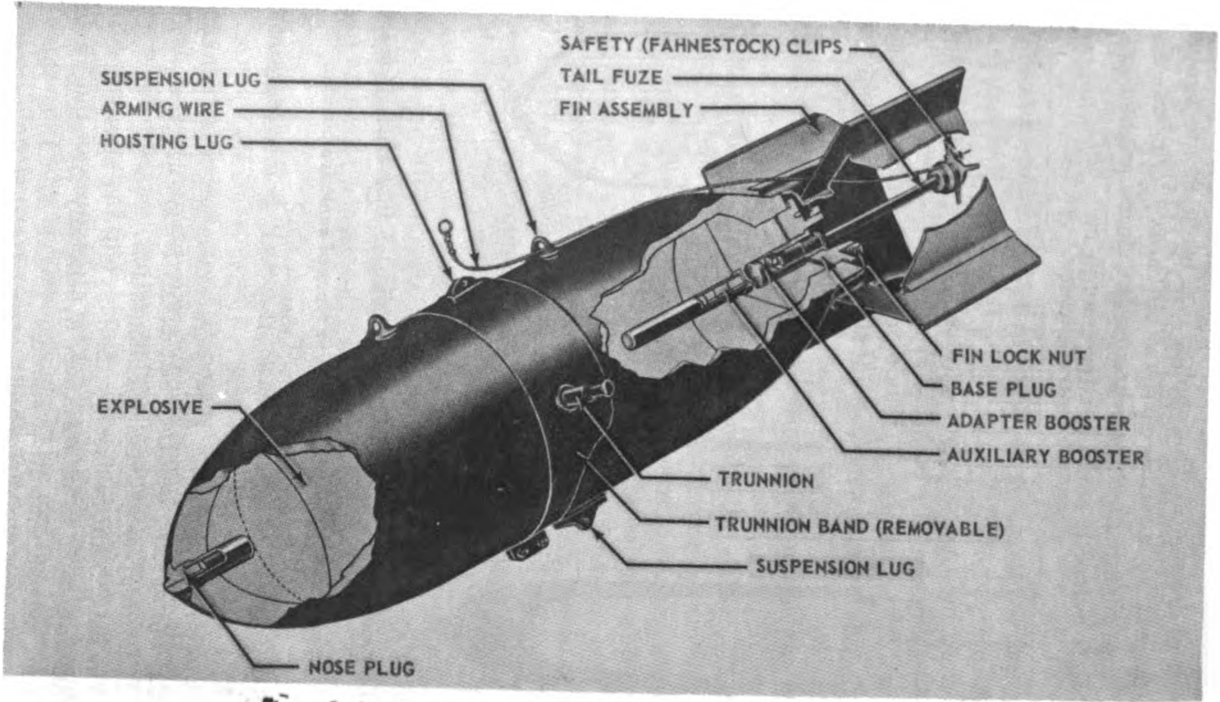


Figure 9-4.—The 1,000-pound semi-armor-piercing bomb AN-M59.

fore and aft, but the forward pocket is rarely used because impact against armor will wreck any nose fuze. The forward fuze pocket is usually occupied by a steel nose plug, as shown in figure 9–4.

Armor-Piercing Bombs

Against the heavy deck armor of battleships or the exceedingly thick concrete of fortifications ashore, the SAP bomb is not very effective. Its case is likely to rupture, practically nullifying its blast effect, and complete penetration is not likely. Against such resistant targets, it is necessary to use a bomb designed primarily for penetration—the ARMOR-PIERCING (AP) bomb (fig. 9–5).

The AP bomb has a heavy steel case with a thickness at the nose as great as 14 inches. The nose section is heat-treated for greater strength, and the outer surface is carefully machined all over to reduce air resistance.

The penetrating ability of the bomb depends on the height at which the bomb is released. If the largest AP bomb is dropped from a sufficient height—about 14,000 feet—to develop its full velocity, it can penetrate nearly 7 inches of armor. This is enough to get through the deck armor of the heaviest warship afloat.

If the bomb is dropped from a lower altitude, as in a dive bombing attack, it loses a great deal of its penetrating power. In a normal dive bombing attack, with release at 3,000 to 4,000 feet, the bomb can pierce no more than 4 inches of armor plate.

With its heavy case (as shown in fig. 9–5), the AP bomb necessarily has a very low loading factor. Its actual explosive power is even less than this loading factor would indicate, because it uses a less powerful burster—Explosive D. When an AP bomb strikes armor plate, the shock is likely to detonate TNT or amatol filler before penetration. Explosive D, less sensitive than TNT or amatol, can resist the impact, but it is also less powerful.

An AP bomb, therefore, does not depend on blast effect to damage its target. When it penetrates to the interior of a

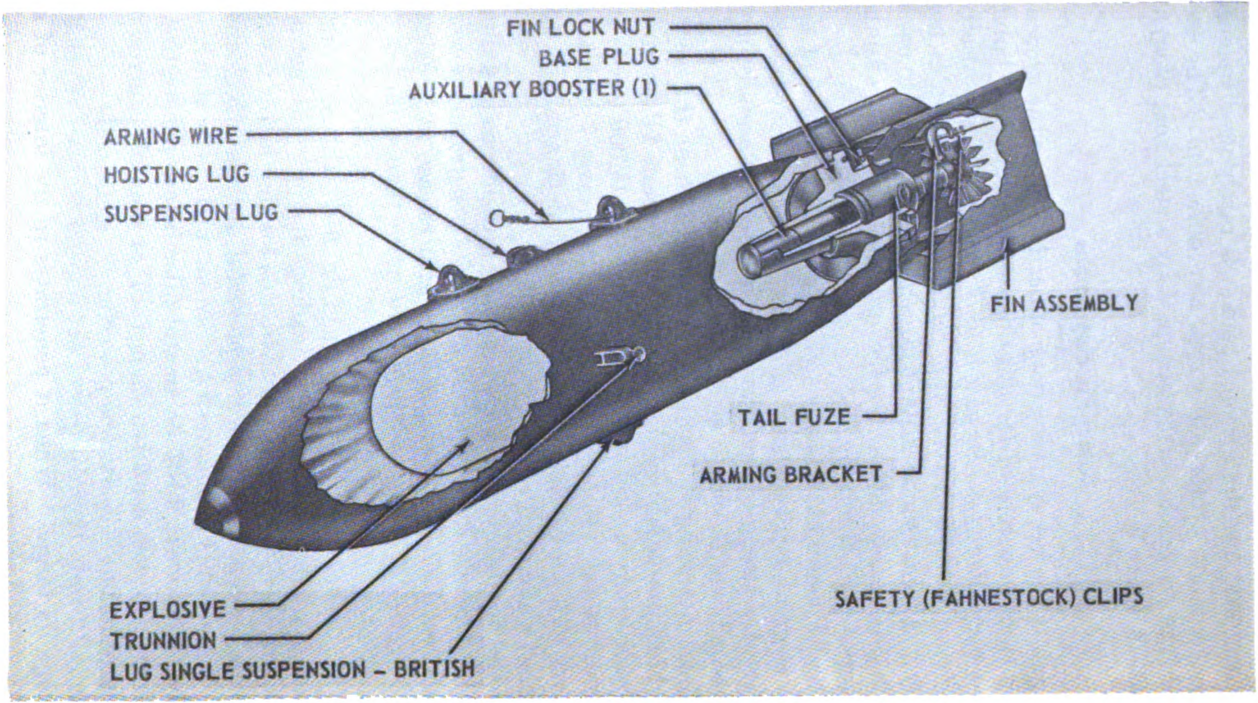


Figure 9–5.—The 1,000-pound armor-piercing bomb AN–Mk 33.

ship and explodes, it does its damage by fragmentation of the case.

Because of its low loading factor, an AP bomb has very little near-miss effect. When a large GP bomb just misses a ship and goes off in the water alongside, the explosion of the bomb will send through the water a shock wave whose pressure against the hull can do considerable damage. The AP bomb does not produce sufficient blast for this.

The AP bomb is used in two sizes—1,000 pounds and 1,600 pounds. AP bombs are fitted with a tail fuze with a short time delay, so that the bomb will penetrate the armor of the target before detonating.

Fragmentation Bomb

Blast is an effective method of demolishing or damaging structures ashore and afloat, but its efficiency against personnel (beyond a relatively limited radius from the point of detonation) is not impressive. For killing and wounding, high-velocity steel fragments are much more effective. The bomb intended for this purpose is the FRAGMENTATION or FRAG BOMB.

Since the number and velocity of fragments are much more important than total concentrated blast effect, fragmentation bombs run rather small as compared to the others we have discussed. (Four to 260 pounds is the present range.) Since their main effect depends on fragmentation, frag bombs have a low loading factor, with a relatively large case designed to fragment easily, and just enough explosive to develop maximum fragmentation and good fragment velocities. Since they are used on exposed or lightly protected targets, fragmentation bombs are not designed or fuzed to penetrate targets before exploding.

In the smaller sizes, they are dropped in bunches or CLUSTERS of three, six, or more. Thus they cover the maximum area with a deadly rain of steel splinters. Figure 9–6 shows the frag bomb cluster AN–M1A1, consisting of six 20-pound frag bombs AN–M41.

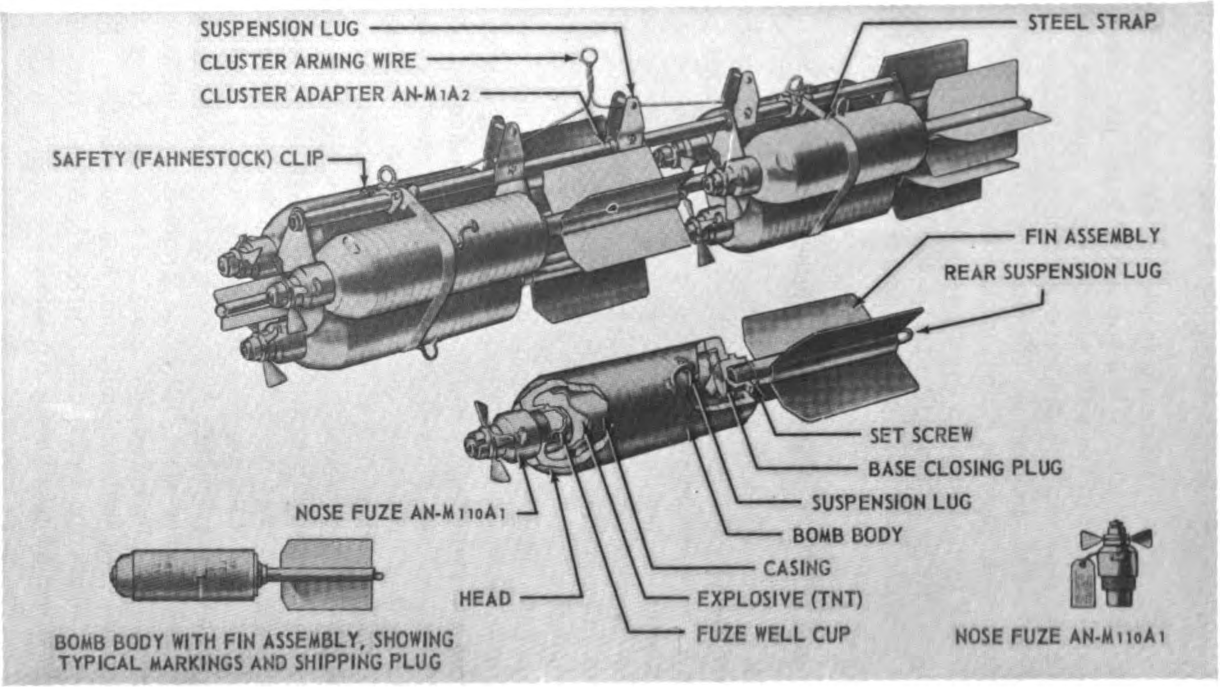


Figure 9-6.—Fragmentation bombs AN-M41 in cluster AN-M1A1.

The present type fragmentation bomb consists fundamentally of a rather small burster with a steel bar of square cross section wrapped around it in a coil. When the burster of the bomb explodes, it splinters the coil into thousands of small fast-traveling fragments. So many fragments are produced that anyone standing within 40 yards of a bursting 20-pound fragmentation bomb cannot avoid being hit by at least one fragment.

A stabilizing fin or parachute is attached to the rear of the bomb so that it will fall nose down. The smaller bombs are fitted with a nose fuze only, so that the bomb will detonate on impact; some of the larger bombs are fitted with both a nose fuze and tail fuze.

Some fragmentation bombs have a parachute case attached aft instead of a tail. The parachute permits release of the bombs from an altitude as low as 70 feet above the target. When the bombs leave the cluster, the parachute opens and the bombs descend slowly, allowing ample time for the plane to fly clear of the area before deadly fragments fly.

Depth Bomb

The last type of explosive aircraft bomb that we shall take up is the DEPTH BOMB—an explosive weapon completely different from the fragmentation bomb in purpose and design. Depth bombs are round-tailed, flat-nosed, light-case bombs with high loading factor (around 70 percent), primarily intended for use against underwater targets (though with appropriate fuzing they can be used against material targets ashore). (Fig. 9–7.) Their principal effect is blast. Underwater, with hydrostatic fuzes, their effect is much like that of depth charges; that is, the shock wave in the water produced by the depth bomb's blast can stave in the side of a submarine if it is close enough, even though the bomb fails to register a direct hit. (Few of them do.)

When fitted with instantaneous nose fuzes, they can be used to blast land targets.

Since depth bomb case fragmentation is ineffective against underwater targets (the fragments are slowed by the re-

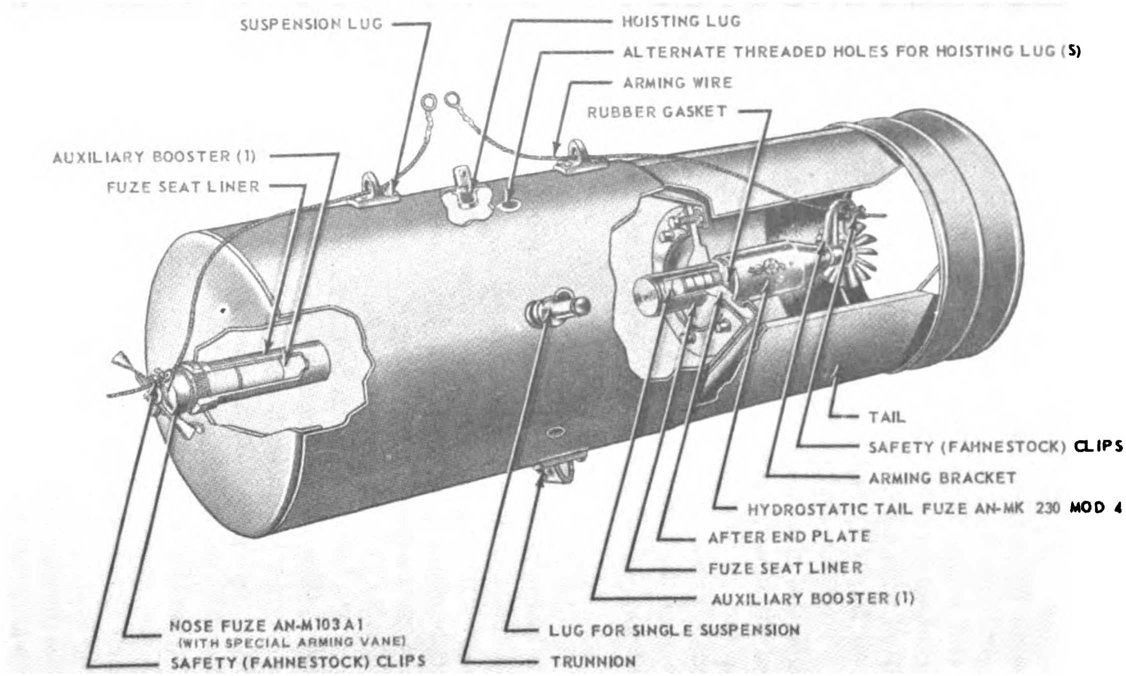

SUSPENSION LUG
HOISTING LUG
ALTERNATE THREADED HOLES FOR HOISTING LUG (S)
ARMING WIRE
RUBBER GASKET
AUXILIARY BOOSTER (1)
FUZE SEAT LINER
TAIL
SAFETY (FAHNESTOCK) CLIPS
ARMING BRACKET
HYDROSTATIC TAIL FUZE AN-MK 230 MOD 4
AFTER END PLATE
FUZE SEAT LINER
AUXILIARY BOOSTER (1)
NOSE FUZE AN-M103A1
(WITH SPECIAL ARMING VANE)
SAFETY (FAHNESTOCK) CLIPS
LUG FOR SINGLE SUSPENSION
TRUNNION

Figure 9–7.—The 350-pound depth bomb AN–Mk 54 Mod 1.

sistance of the water), and since the bomb is not designed to pierce anything more substantial than the surface of the briny deep, the depth bomb needs only a case thick enough to hold it together when it hits the water.

There used to be two principal sizes of depth bomb—one about 350 pounds loaded, the other about 650 pounds loaded. The larger size is now obsolete, and you are not likely to encounter any. The present issue depth bomb—there is only one at this time, the AN–Mk 54 Mod 1—runs 350 pounds gross weight, Torpex-loaded. This depth bomb (fig. 9–7) is shorter and fatter than other American bombs. It has a flat nose and a round instead of square tail. It is fitted with a nose fuze AN–M103A1 or AN–Mk 219, which detonates the bomb on impact. At the tail is a HYDROSTATIC fuze AN–Mk 230 Mod 4, which functions to detonate the bomb when it reaches a certain depth of water, much like a depth charge. All depth bombs require careful handling because their thin cases are easily dented or cracked.

Depth bombs are sometimes dropped on surfaced submarines or other surface craft, and even on ground targets where maximum blast is desired instead of penetration or fragmentation. When a depth bomb is dropped in normal fashion, to go off under water, the nose fuze is omitted or is dropped safe, so that it will not operate.

On the Mk 54 Mod 1 depth bomb, external permanent fittings and lugs have been eliminated; instead, provision is made for assembling these to the bomb case as needed.

Since round-nosed bombs tend to ricochet when they hit the water at a sharp angle, depth bombs are now flat-nosed. (Older round-nosed types used to be fitted with flat-nose adapters, but you are not likely to encounter them any more.)

CHEMICAL BOMBS

The bombs you have read about so far are HIGH EXPLOSIVE bombs which do their work by exploding the filler and creating blast, fragments, or both.

The other main type of service bomb is the CHEMICAL.

These depend on chemicals that produce effects other than blast or fragmentation to do their work. Chemical bombs can be divided into three main classes: GAS, SMOKE, and INCENDIARY.

Gas and smoke bombs contain a chemical agent filler surrounding a core of explosive which, when it is detonated, breaks the casing and scatters the filler. Although stocks of war gas ammunition are stored for possible use by United States Armed Forces, you are not likely to find it in the Fleet because United States policy is to use it only if the enemy uses it first.

Smoke Bombs

No such restriction applies to smoke ammunition, and you will find it in the Fleet. The commonest type of smoke bomb is WHITE PHOSPHORUS (WP). The filler is the same as that in WP-loaded gun ammunition and, on the whole, the smoke bomb is similar to the gun projectile in that its filler is scattered by detonation of a high-explosive filler (tetryl is commonly used) initiated by a nose fuze.

Incendiary Bombs

While gas and smoke bombs are not unlike the corresponding gun ammunition in their internal arrangements and functioning, incendiary bombs are quite different from the small-caliber incendiary gun projectiles that you have encountered up to now.

Incendiary bomb design is closely related to the target the bomb is to be used against. You may be aiming at light combustible structures such as the temporary buildings around an airfield, or you may be trying to set afire solid, permanent buildings like those in cities. Corresponding to these two types of target, you will find two types of incendiary bombs. (Fig. 9–8.)

Incendiary bombs designed for use against light inflammable targets are filled with a mixture of oil or gasoline with a composition called NAPALM. The mixture, called OIL GEL, is a sticky combustible material something like

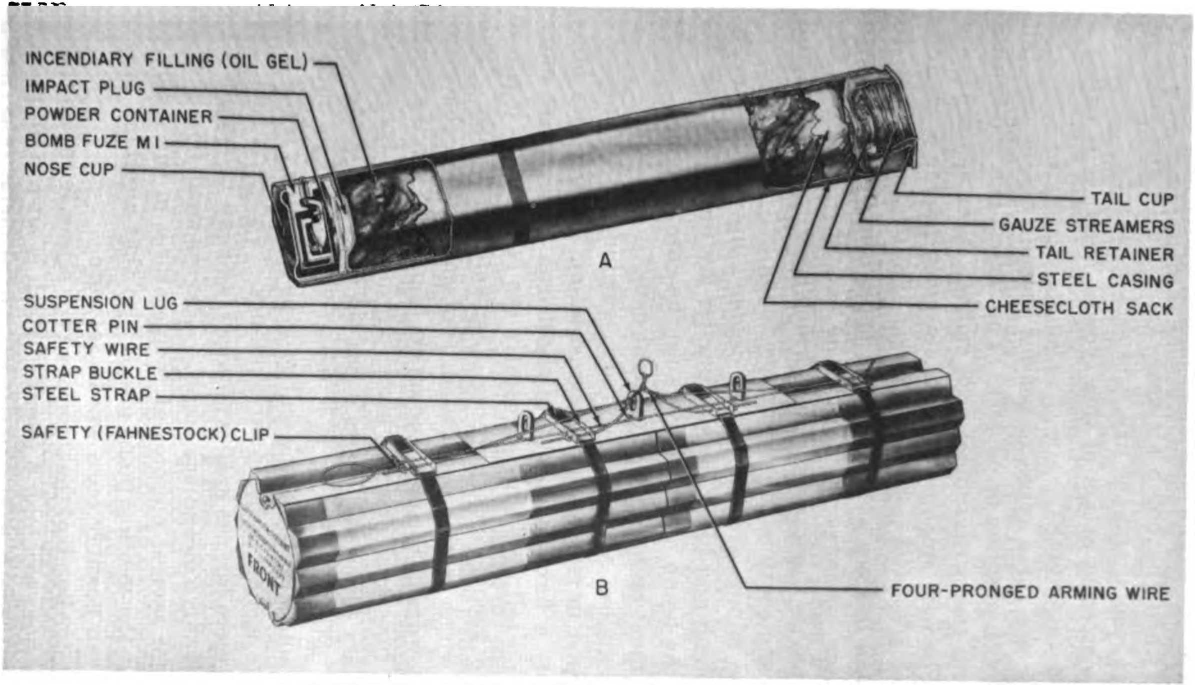


Figure 9–8.—Incendiary bombs. A. 6-pound scatter type (one of a cluster). B. Cluster of 4-pound intensive incendiaries.

rubber cement. The incendiary filler is ignited and scattered around when the bomb strikes. It sticks to the sides of buildings, tents, and the like, and sets them afire. Because of the scattering action of this type of bomb, it is called a SCATTER INCENDIARY.

There are three types of scatter incendiaries in use (all loaded with gasoline or oil gel). The largest is a 500-pound GP bomb case with impact nose and tail fuzes and separate tail. The next smaller type is a 100-pound bomb with nose fuze and a case of light sheet metal about $\frac{1}{32}$-inch thick to which tail fins are welded. Both types contain tubes down the center (BURSTER WELLS) for the burster. In action, the fuze explodes the burster charge which ruptures the case and ignites and scatters the incendiary filling.

These bombs are shipped to depots empty. The incendiary filling and black powder burster are put in by the AO before the bomb is used. Because the case is so thin, these bombs must be handled with great care.

The smallest scatter incendiary, weighing only 6 pounds, is dropped in clusters like fragmentation bombs. Its body is simply a hexagonal tube of sheet iron with square ends. It has no tail, but cloth streamers are fastened to it aft in order to keep it heading nose downward as it falls. This bomb, which is shipped loaded, contains a small charge of black powder in the nose and oil gel filling. When the bomb hits, a fuze explodes the black powder, which ignites the incendiary filling and blows it out the after end of the tube.

Well adapted though it is for attacking targets such as light frame structures, the scatter-type incendiary is not very effective against substantial buildings. To ignite such targets, a more intense heat is required, and can be supplied by the INTENSIVE incendiary bomb. This is a small bomb which burns for several minutes at temperatures in the neighborhood of the melting point of steel, so that anything near it which can possibly burn will be set afire.

Only one bomb of the intensive type is now in regular use—a small one, weighing 4 pounds, which is always dropped in clusters. The bomb case is a hexagonal metal tube, not of sheet iron but of magnesium. As any photography fan will tell you, magnesium is a lighweight metal that burns so easily and intensely that it is used in photographic flash equipment.

The bomb filling is THERMATE OF THERMITE—a mixture of aluminum powder and iron oxide (rust) which, when it burns, produces temperatures high enough to melt iron.

This bomb does not have a tail, but the after end of the sheet metal body is empty, making the bomb nose-heavy, and so keeping it headed in the right direction as it falls.

When the bomb strikes, a fuze ignites the thermate. The thermate filler and the magnesium body burn for 10 minutes or more at a temperature of nearly 2,500° F.

In each cluster of these incendiary bombs, some bombs are loaded with an explosive charge which goes off after the bomb has burned for 1 to 4 minutes. This charge, which is big enough to kill anyone nearby, is intended to discourage people from trying to pick up the burning bombs with long-handled shovels. Enemy incendiary bombs also have this feature. That is why you should wait at least 4 minutes before attempting to deal with an incendiary bomb.

Practice Bombs

Just as target practice ammunition is issued for the training of shipboard personnel in gunnery, so the Navy issues practice bombs for aircrew training. There are two types: MINIATURE PRACTICE BOMBS and WATER-FILLED OF SAND-FILLED BOMBS.

The MINIATURE PRACTICE BOMB is a small teardrop-shaped slug of cast iron or lead-antimony alloy, weighing from 3 to 13 pounds. It has small fins cast into it and is designed to fall in practically the same path that a full-size bomb would follow. Like many gun target practice projectiles, it contains a SPOTTING CHARGE. Into a hole running lengthwise through the center of the bomb is inserted a charge of black powder in a paper cartridge resembling an oversized shotgun shell. A small striker in the nose sets off the charge when the bomb hits the ground.

ALWAYS remember that, once the spotting charge has been inserted, these innocent looking little slugs of metal are MORE

DANGEROUS to handle than any other bomb the Navy uses. Service bombs can be safetied while they are being handled, but these little practice bombs are ALWAYS ARMED. See that they are always handled with the precautions that this implies.

To provide more realistic bombing practice, larger practice bombs are used. These are the size of 100-pound, 500-pound, and 1,000-pound GP bombs. They are sheet metal affairs resembling GP bombs except that the tails are welded on. They are filled either with SAND or WATER. Filled with wet sand, they weigh as much as the bombs they are intended to resemble; with water filling, they weigh about half that.

These water- and sand-filled bombs are relatively fragile and must be handled with care. Particular care must be taken not to dent or bend the fins. Bending the fins will distort the trajectory and nullify the training value their use is expected to provide.

BOMB HANDLING AND STOWAGE

As a Chief or First Class Gunner's Mate, you are not likely to do much handling of bombs directly; but, if you are aboard an aircraft carrier, you may have to work closely with Aviation Ordnancemen in below-decks work with bombs. This section is intended to serve as an introduction to typical bomb-handling operations. It won't make you an expert on aircraft bomb handling—that's for the AO or (depending on circumstances) for bomb-disposal personnel—but it will help you understand some of the problems and methods of personnel primarily charged with responsibility for airborne ordnance.

Bomb Assembly

As you already know, bombs are generally stowed and shipped only partly assembled. Tail assemblies, fuzes, and often suspension and hoisting lugs, are not mounted on the bomb until just before it is to be loaded into the aircraft.

The most critical item to be assembled to an aircraft bomb is its fuze. These are shipped separately in sealed metal containers. Fuzes are usually installed in the bomb AFTER it is loaded into the airplane and after all other attachments (fins, lugs, etc.) are assembled to it.

To fuze a group of bombs, the AO first assembles the CORRECT number of the proper fuzes in their containers. Next, he removes the TRANSPORTATION PLUGS from the fuze pockets of the FIRST bomb to be fuzed. (In Navy-designed bombs—including all depth and AP bombs—a Mk 1 auxiliary booster will be found loose in the fuze pocket. If it is missing, the AO must obtain another Mk 1 booster to replace it.)

Next, he inspects the threads of the fuze pocket carefully to be sure there is no dirt or TNT exudate. If dirt or exudate are present, it is necessary to wrap a cloth around a stick and swab out the fuze pocket. Metal tools must never be used to clean a fuze pocket.

He then removes the fuzes from their containers. Most fuzes have no vanes on them; arming vanes are shipped separately. The arming vanes of some fuzes snap on; others are fastened with a nut; others, with a cotter pin.

Standardized Army fuzes always contain two or more pairs of eyelets through which an arming wire can be threaded to prevent rotation of the arming vane. When the fuze is unpacked, the AO will find a cotter pin run through one of these pairs of eyelets to prevent rotation. He will also find a short loop of wire run through another, and fastened with a lead seal. This is the CAR SEAL. If the car seal or wire has been tampered with, the fuze should be turned over to an officer for inspection.

The next steps are to cut and remove the car seal wire (leaving the cotter pin in place), screw the fuze into the fuze pocket, and tighten it up snugly hand-tight. AN fuzes of Army origin are usually secured hand-tight only.

The AO then runs an ARMING WIRE through the suspension lugs of the bomb, placing it so that the eyelet of the arming wire is about midway between the suspension lugs, and threads its free end through the NEAREST pair of eyelets on the fuze. The cotter pin is left on the fuze until the bomb is in the airplane.

Next, he attaches the arming vanes. After the bomb has been secured to the bomb rack or shackle, he attaches the arming wire eyelet to the arming wire hook on the rack, draws the wire out straight, and cuts it off about 3 inches beyond the fuze. He uses emery paper or fine sandpaper to remove any burring of the ends of the arming wire. He then slips two Fahnestock clips over the end of the wire, bringing them up snugly against the fuze.

Navy NOSE fuzes are installed in almost exactly the same way except that no car seal will be found on the fuze, and the fuze is tightened with a small spanner wrench.

On Navy-designed bombs, TAIL fuzes are fastened to the arming wire in a different way. Welded to the inside of the bomb tail is an ARMING WIRE BRACKET. After the fuze is in the bomb, the arming vane is attached to the fuze so that it can rotate between the arms of the bracket. The arming wire is then threaded through holes in the arms of the bracket so that it runs between two blades of the vanes. If the bomb is to be suspended outside the airplane, an arming wire guard of copper tubing must be slipped over the arming wire between the arms of the bracket. You can see the guard in figure 9–9, *A*.

Some types of bombs have no arming wire brackets on their tails. Therefore, an arming wire BRACKET ADAPTER (fig. 9–9, *B*) must be attached to the fuze. The arming wire then is threaded through the adapter as through a bracket.

TAIL HYDROSTATIC fuzes are installed on bombs in the same manner as Navy tail impact fuzes.

Handling Bombs Aboard Ship

As in handling ANY explosive ammunition, the primary consideration in bomb handling aboard ship is SAFETY. Though the high explosives used in bomb bursting charges are relatively insensitive, it is not wise to abuse this characteristic. Moreover, though one bomb detonation may be bad enough, one bomb can set off an entire magazine chain-fashion. There can be no relaxation of safety precautions on any ship with bomb-type ammunition aboard.

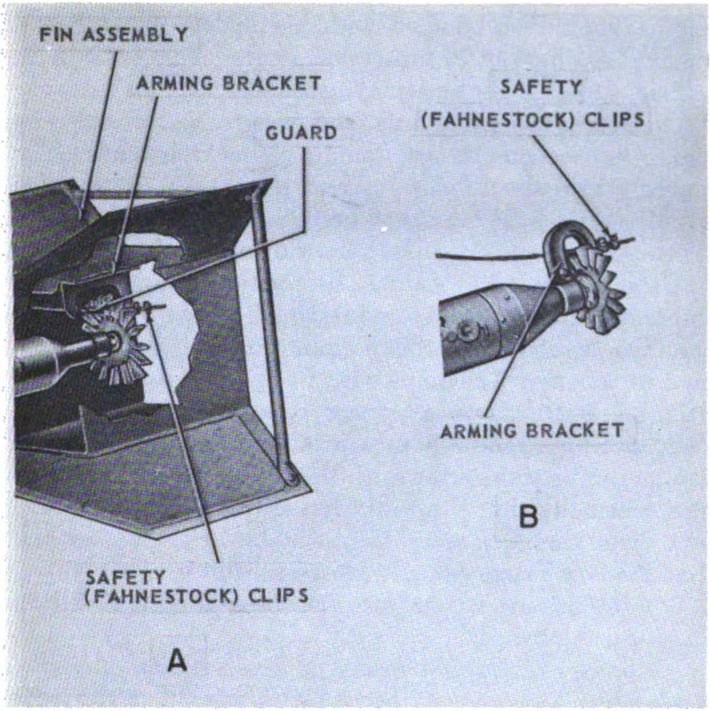


Figure 9–9.—Tail fuzing of Navy bombs. A. Arming wire and bracket in tail of fuzed bomb. B. Bracket adapter and arming wire on tail of fuzed bomb.

It is not safe, for example, to expect completely consistent behavior from high explosives. In some cases on record, bombs filled with any of several high explosives, varying in sensitivity from relatively touchy Torpex, to tranquil TNT, have dropped from considerable heights without detonating. But there are cases where they have detonated from drops of only a few feet, or because of rough handling. It is clear, then, that the reaction of high explosive fillers to the shock of a fall or rough handling is unpredictable. High explosives in ANY form must be handled with care and protected from drops or jolts. All containers of explosive must be protected from injury.

Bomb-type ammunition having thin containers, like depth bombs, should be handled with particular care. The thin metal case offers little protection to the explosive. A blow sufficient to dent the case may detonate the explosive charge.

The relatively great bulk and weight of aircraft bombs makes it necessary to use handling machinery and gear to manage them aboard ship. There are several types of bomb CARRIERS designed for use in handling bombs without crates or shipping bands. Since the carriers utilize the bomb suspension lugs, they cannot be used on bombs fitted with shipping bands. They are designed primarily for use in handling bombs with trolley chain hoists, but they may be used in transferring bombs with booms or cranes.

Figure 9–10 shows a carrier being used with a trolley chain hoist to handle bombs in a ship's magazine. Heavy bombs can be transferred with the trolley chain hoist by one man when the ship is on an even keel. If the ship rolls or lists even slightly, more men will be necessary to ensure that the bomb does not get away and run wild.

Bomb skids or trucks are also used for moving bombs about on shipboard.

Methods of taking bomb-type ammunition aboard are similar in many ways to those for large-caliber gun ammunition. Pendants, straps, or slings are usually used in hoisting bombs that are fitted with shipping bands and bombs (such as AP) that have no suspension lugs assembled. There are several different types and arrangements of straps in use and each one has its advantages and disadvantages. The pendants, straps, or slings should be made of wire rope of sufficient strength to support the load with a good margin of safety.

The pendant, strap, or sling should be positioned on the bomb so that the bomb is balanced and cannot slide out. In hoisting a load of two or more bombs, it is important to prevent the bombs from bumping together when the load is lifted clear of the deck. This may be done by placing the bombs together before hoisting, by easing the bombs together as they are lifted, or by placing timbers or some other material between them.

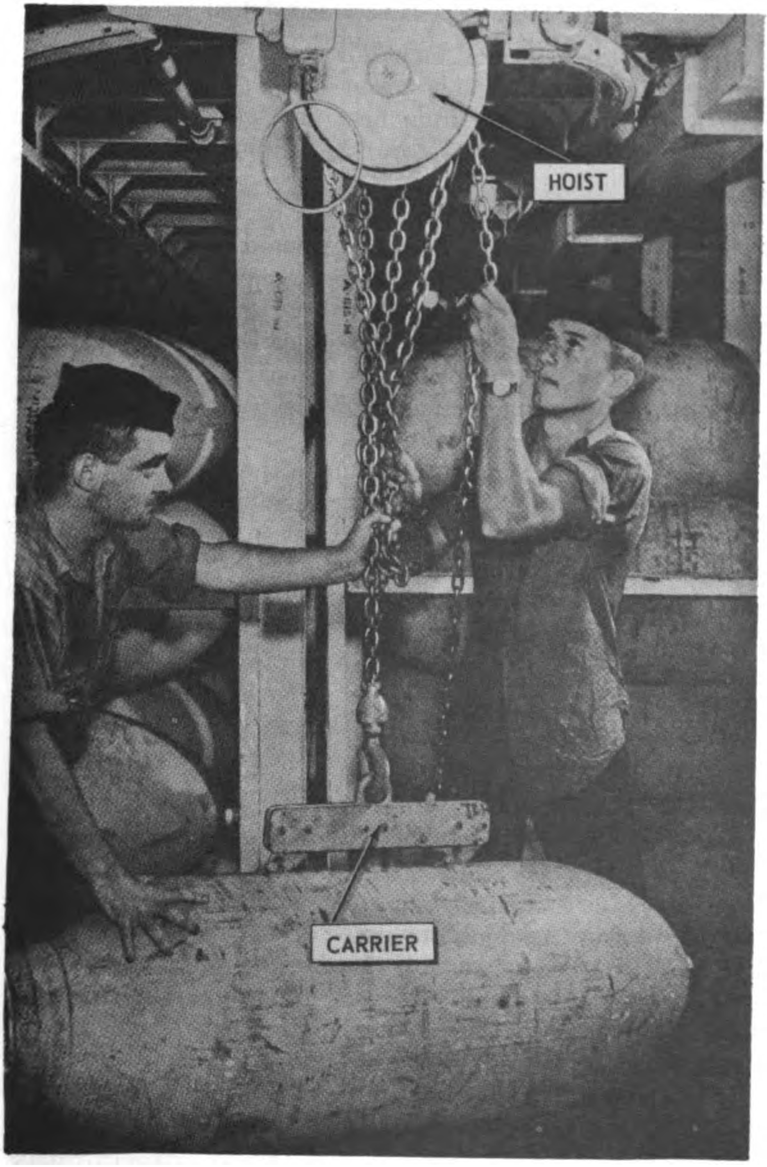


Figure 9-10.—Using trolley chain hoist and bomb carrier in a ship's bomb magazine.

Bomb Stowage Ashore and Afloat

Here are some general rules for the guidance of bomb-handling personnel in bomb stowage both ashore and afloat:

1. Keep bombs away from heat and keep them out of direct sunlight. Ashore, store them under a roof or a tarpaulin.

2. Remember that bomb cases can be dented by rough handling and can rust if they are exposed to moisture and dirt.

3. Fuzes must NEVER be stored in a bomb magazine (except when they are shipped assembled in a bomb cluster). They should be kept in separate fuze lockers, well separated from other explosive material. Fuzes contain the most sensitive and dangerous explosives.

> NOTE. An exception to this rule is the ready magazine. Under certain conditions, it is permissible to store bombs and fuzes together in advance of use. In this case, they should be properly guarded against unauthorized personnel.

4. Standardized Army fuzes are built so that they require no maintenance. It is not permissible to attempt to disassemble or clean a standardized Army fuze. If these fuzes have been exposed to weather or salt spray as much as 2 weeks, they should be removed from the bomb, returned to a depot or thrown overboard in deep water, and replaced by fresh fuzes.

MINES

Naval mines are not bombs, but they are considered "bomb-type" ammunition. They are thin-cased, high-explosive-filled ammunition and are designed to explode under water when touched or closely approached by a ship. They are unique, compared with other ammunition you have studied, in that they don't "go after" their targets. When planted and armed, they await any submarine or surface ship that may approach close enough to actuate their mechanisms. Of course, they can make no distinction between enemy, neutral, or friendly targets; once planted, mines are dangerous to ALL craft.

Mines are employed offensively or defensively and may be laid by aircraft, submarines, or surface vessels. The main explosive charge of United States mines, which may consist of either TNT, Torpex, or HBX, is cast into the mine case.

Types of Mines

There are three general ways of classifying mines:

1. By position in the water.
2. By type of firing mechanism.
3. By type of launching craft.

Each group includes three different types. According to position in the water after launching, mines are classified as MOORED, DRIFTING, or GROUND.

A moored mine is laid in deep water where enemy shipping is expected. The mine is moored so that it will not drift from the path of enemy shipping and endanger our own or friendly ships.

The drifting mine is laid in an ocean current, or in a river, where the drift will be toward a focal point of enemy shipping. It floats on the surface or at a set depth below the surface. Drifting mines usually contain a self-destructive or sinking device, designed to detonate the mine or sink it harmlessly after a predetermined length of time. Such devices are required by international law for the protection of neutral shipping, and also safeguards our own ships.

Certain "drifters" are sometimes called "oscillating" mines because they tend to oscillate gently up and down as they drift along under the water's surface. This oscillation is caused by the functioning of a buoyancy chamber and hydrostatic mechanism which keep the mine at a preset depth.

The ground mine is laid in shallow waters (except when laid to intercept submarine traffic) and it sinks at once to the bottom. The mine's own weight holds it in place. Because a ground mine lies farther away from the target ship, it uses a relatively greater explosive charge. This adds to its weight so that no anchor is necessary.

Types of mines, classified by firing mechanism, include CONTACT, INFLUENCE (magnetic, acoustic, or pressure-activated), and CONTROLLED.

Contact mines require actual contact between the target ship and some part of the mine. They may be actuated by inertia, or by GALVANIC or ELECTROCHEMICAL effects. The galvanic type energizes a firing circuit when any steel object touches a copper part of the mine. The electrochemical type has horns attached to the mine case. When a horn is crushed by contact with a ship's hull, it breaks a vial of acid; the acid flows into a receptacle where it becomes the electrolyte of a battery, and the resulting current energizes a firing circuit.

There are three types of influence firing mechanisms for mines—MAGNETIC, ACOUSTIC, and PRESSURE-ACTIVATED.

The magnetic type is further subdivided into two types: the DIP NEEDLE and the INDUCTION. The heart of the dip needle type is a needle balanced so that when it lies in the normal magnetic field of the earth, it holds the mine firing circuit open. When a ship passes near, the magnetism of its steel hull distorts the normal magnetic field and causes the needle to dip. This closes the electrical circuit to detonate the mine.

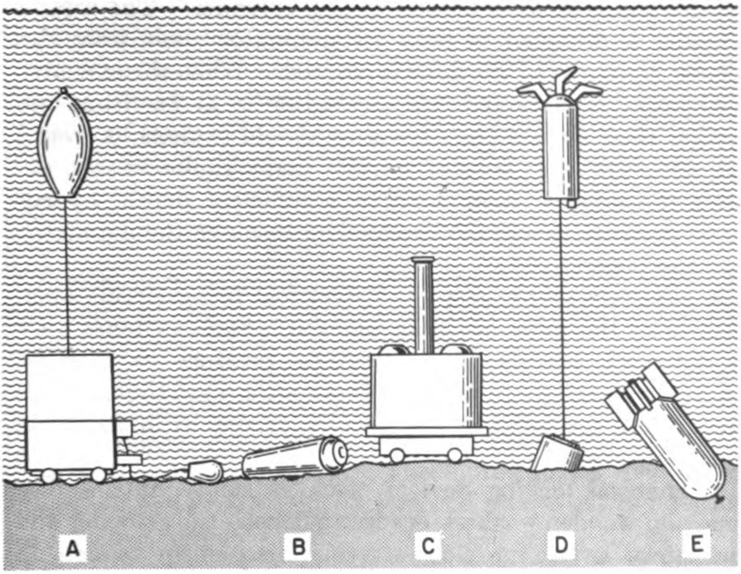
The acoustic mine is fired by the action of sound waves produced by a passing ship on a sensitive microphone in the mine.

The pressure-activated mine detects the changes in water pressure caused by a passing ship.

Controlled mines have a firing mechanism that can be energized from a remote control station. They are ground types, and contain influence-type detection devices to signal the presence of ships. Mines of this type are defensive in purpose.

A single mine may incorporate more than one type of firing mechanism.

Finally, mines are classified by the type of craft that launches them, as SURFACE SHIP, AIRCRAFT, or SUBMARINE. Some mines may be modified so that they may be launched from more than one type of craft. Mines laid by aircraft



A. MOORED CONTACT MINE (SURFACE-LAID).
B. GROUND MAGNETIC MINE (AIRCRAFT-LAID).
C. GROUND MAGNETIC MINE (SURFACE-LAID).
D. MOORED CONTACT MINE (SUBMARINE-LAID).
E. GROUND ACOUSTIC MINE (AIRCRAFT-LAID).

Figure 9–11.—Types of mines and their positions after planting.

must be constructed to withstand the shock of hitting the water.

Figure 9–11 shows the different types of mines and their positions in the water after planting.

Mine Safety Features

Various safety devices prevent mines from exploding prematurely. The EXTENDER and the SAFETY SWITCH are two such devices which are common to all United States Navy mines. Their mechanical details may differ slightly in various mines, but the basic operational features remain the same.

The function of the mine's extender is similar to that of the depth charge's booster extender except that, in mines, the detonator itself is moved by the extender. The mine's extender is designed to hold the detonator away from the booster charge until the mine is planted. When the extender mechanism is retracted, the detonator is so far from the booster that, even if the detonator should explode, it would not detonate the booster or the main explosive charge. After the mine is submerged to a sufficient depth, hydrostatic pressure causes the mechanism to move the detonator into the booster can.

A SAFETY SWITCH keeps the electrical firing circuit open until after the mine has been planted. Such switches may be actuated directly by hydrostatic pressure or may be closed by a CLOCK DELAY MECHANISM after a set time. Such clock delay mechanisms are usually driven by hydrostatic CLOCK STARTERS.

Mechanical locking devices, such as safety nuts, safety pins, and wooden washers, ensure that both the extender and the safety switch or clock-starting mechanism remain in SAFE position during transportation and handling. These locking devices must be removed before planting or the mine will not arm. SOLUBLE WASHERS are frequently added to hydrostatic safety devices to delay arming until the washers have been dissolved by sea water.

There are also a number of accessories on mines for added safety in handling the mine, to reduce the effectiveness of enemy countermeasures, or to permit safe passage of our forces after a predetermined date. Such accessories include STERILIZERS and SHIP COUNTERS.

Sterilizers render mines safe after they have been armed for a certain length of time. Sterilizers may be part of the clock delay mechanism, or they may be separate units. An electrolytic sterilizer in common use consists of copper electrodes and an electrolyte of sulfuric acid, copper sulfate, and distilled water. Current, supplied by a low-voltage battery, breaks the anode down electrolytically until a spring-loaded plunger is released. The release of this plunger may open the detonator circuit, or fire the mine, or (in moored mines) actuate a small scuttling detonator, sinking the mine.

Sterilizing mechanisms may be set to function up to 350 days after planting.

SHIP COUNTERS permit the firing mechanism to be set to fire the mine only after it has been actuated a predetermined number of times. Such actuation is usually termed a "look." The number of "looks" required to fire the mine can be varied.

Special-Purpose Mines

Special-purpose mines are designed for special missions, and don't fit exactly into the classifications described in the preceding paragraphs. Here are a few:

A self-propelled TORPEDO MINE permits a submarine to lay mines in water too shallow for safe navigation of the sub. The sub approaches close to where the mine is to be planted, then fires it like a torpedo. The mine propels itself a set distance, then sinks to the bottom and arms itself to function as a ground influence mine.

Moored ANTISWEEP DEVICES are interspersed in moored mine fields. They are designed to explode and destroy sweep wires when such wires strike the mooring cable or float.

Other special-purpose mines are LIMPET MINES, which are stuck to their targets by swimmers, and BEACH-DEFENSE MINES which are ground mines laid in shallow water. They explode on contact with landing craft.

Only a few years ago, Gunner's Mates (and Torpedomen) were the Navy's mine experts. Now Minemen have a distinct rating of their own. It is therefore obvious that in the next few pages it will not be possible to make a mine expert of you; but, by going into some slight detail on three relatively common types of mine, you can gain some idea of the Mineman's weapons.

Typical Moored Contact Mine

One of the oldest, and still one of the most widely used and most typical of moored contact mines is the mine Mk 6 and mods. It therefore deserves some further attention.

The Mk 6 (fig. 9–12) consists of an ANCHOR assembly, a

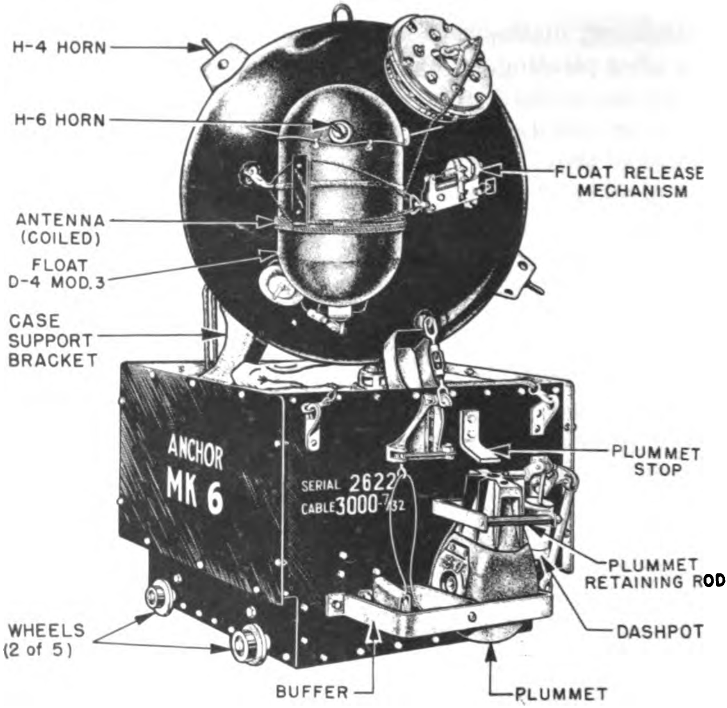


Figure 9-12.—Mk 6 mine assembly.

CASE assembly, and a FLOAT assembly. The three major units are held together by devices which automatically release them from each other after launching.

The anchor is a steel box 2¼ feet square and 2 feet deep, mounted on four wheels. A fifth wheel functions to start the process of separating the anchor from the case. The separation is initiated by the plummet assembly, a pear-shaped iron casting used to regulate the mine's depth when planted. Three brackets atop the anchor support the mine case. The anchor casing contains a drum on which the mooring cable is wound, a drum brake, and a pawl mechanism to lock the drum after the proper length of cable has been unwound. For deep planting, a parachute attached to the anchor retards its sinking rate.

The case is a steel sphere 34¼ inches in diameter. On its surface are four horns (also called H-4 devices) which actuate the firing mechanism, a lifting eye on the top and a mooring eye on the bottom, three anchor securing hooks, and two float securing hooks. Inside the case are the firing mechanism, detonator, extender, booster, battery, and wiring, plus the charge of TNT. During shipment, an opening at the top for the firing mechanism and one at the bottom for the extender mechanism are closed with wooden covers, and the four openings for the horns are closed with wooden plugs.

The float assembly is secured to the side of the case. It includes a release mechanism which functions hydrostatically to free the float assembly after the mine is in the water. The float is a steel cylinder about 1 foot in diameter and 1½ feet long, wrapped with a copper antenna which streams out when the mine is planted. The extended antenna increases the chances of target contact. In some types, there are also three horns (H-6 devices) on the float. (H-6 and H-4 horns function on similar principles.) The mine will detonate if a ship's steel hull strikes the case horns, the antenna, or the float horns. A wooden hull will not actuate a mine by contact with the antenna, but it will if it hits an antenna float with horns.

Planting the Mk 6 Mine

Like most mines, the Mk 6 functions through a rather complex chain of operations. (That's why Minemen usually call their stock in trade "Rube Goldbergs.") The Mk 6 is no exception. Here is what happens when it is planted (follow the sequence of operations in fig. 9-13):

Mk 6 mines aboard minelayers are stowed on tracks. To plant the assembled mine, it is rolled (on its five wheels) off the stern. As it leaves the tracks, the fifth wheel drops down and releases the plummet, but the plummet doesn't actually drop off at once; an oil-filled dashpot delays it for about 8 seconds, during which the buoyant mine assembly bobs back up to the surface, rights itself with the case up, and steadies itself.

As the plummet descends, a cord inside it unwinds from a spool. When all of the cord is unwound, the jerk of the heavy plummet pulls the slip link off the slip hook, allowing the case and anchor to separate. A flooding valve in the anchor opens and the anchor sinks, unreeling mooring cable from the cable drum while the case continues to float on the surface.

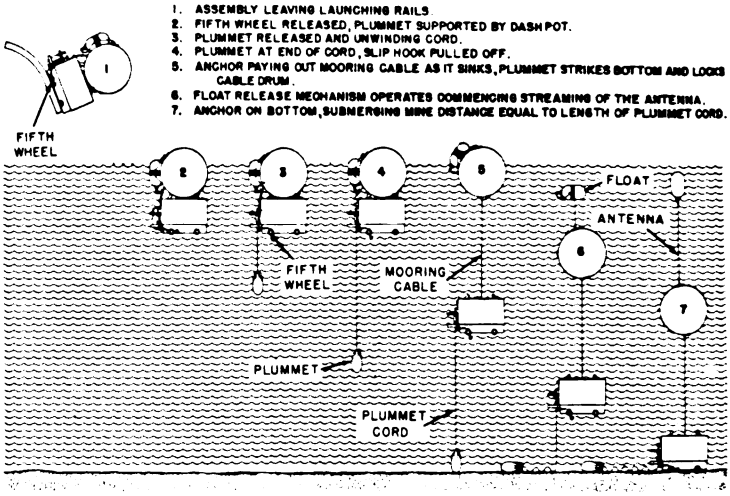

1. ASSEMBLY LEAVING LAUNCHING RAILS.
2. FIFTH WHEEL RELEASED, PLUMMET SUPPORTED BY DASH POT.
3. PLUMMET RELEASED AND UNWINDING CORD.
4. PLUMMET AT END OF CORD, SLIP HOOK PULLED OFF.
5. ANCHOR PAYING OUT MOORING CABLE AS IT SINKS, PLUMMET STRIKES BOTTOM AND LOCKS CABLE DRUM.
6. FLOAT RELEASE MECHANISM OPERATES COMMENCING STREAMING OF THE ANTENNA.
7. ANCHOR ON BOTTOM, SUBMERGING MINE DISTANCE EQUAL TO LENGTH OF PLUMMET CORD.
1
FIFTH WHEEL
2
3
4
5
FLOAT
ANTENNA
6
FIFTH WHEEL
MOORING CABLE
7
PLUMMET
PLUMMET CORD

Figure 9-13.—Planting the Mk 6 mine.

When the plummet strikes bottom, the plummet cord slackens, permitting a spring-loaded pawl to engage a ratchet on the cable drum. This locks the drum and no more anchor cable will pay out. The anchor, now full of water, pulls the case beneath the surface to a depth equal to the length of the plummet cord.

When the float assembly, attached to the case, is pulled under, water pressure operates the float release mechanism. The released float streams upward and unreels the antenna. But the lower end of the antenna is still attached to the case so when the antenna is extended full length the float follows the case downward until it reaches its proper level beneath the surface of the water.

The mine is now moored and ready to be armed.

The depth at which the mine is moored depends on the length of the cord on the plummet spool. For example if this cord (steel wire rope) is 100 feet long the mine case will come to rest 100 feet below the surface of the water. The effective length of the cord is stenciled on the outside of the plummet when the spool is installed.

Arming the Mk 6 Mine

After the mine has been prepared and launched it must be armed.

The firing system of a mine of the Mk 6 type consists of a booster can, detonator, extender, hydrostatic switch, sea battery, dry cell battery, horns, and antenna. Before the mine is armed water pressure must do two things—extend the detonator into the booster, and close the firing switch. The electric system, actuated by a passing ship, does the rest.

The booster can loaded with granular TNT, is installed in the upper end of the central tube. Its base rests on top of the extender mechanism. In the lower end is a pocket for the detonator.

The detonator contains fulminate of mercury and a wisp of guncotton. Electric current through a bridge wire ignites the guncotton, which sets off the fulminate.

The extender moves the detonator into the booster pocket to arm the mine when sea water pressure depresses a rubber diaphragm installed at the lower end of the extender. This moves a piston inward, in turn operating a linkage which carries the detonator inward.

A steel cover fits over the diaphragm. Water is admitted to the diaphragm through a hole in the cover. A safety nut keeps the extender piston retracted, and prevents entry of water. It must be removed before launching or water will not enter, the extender will not operate, and the mine will be a dud.

Complete operation of the extender may be delayed up to 3 days by installing a soluble washer assembly in place of the safety nut. The extender cannot move until the washer dissolves.

While the use of this washer is optional, depending on conditions, another soluble washer is ALWAYS used in the firing mechanism installed at the top of the mine case. This washer must dissolve before the hydrostatic piston stem of the safety switch in the firing mechanism can move inward. When the stem does move, the switch closes and the mechanism is armed.

The Mk 6 mine's electrical firing mechanism uses two circuits—a **SEA BATTERY** (exterior) **CIRCUIT** and a **DRY CELL** (interior) **CIRCUIT**. The sea battery of the exterior circuit is like all other chemical batteries in consisting basically of

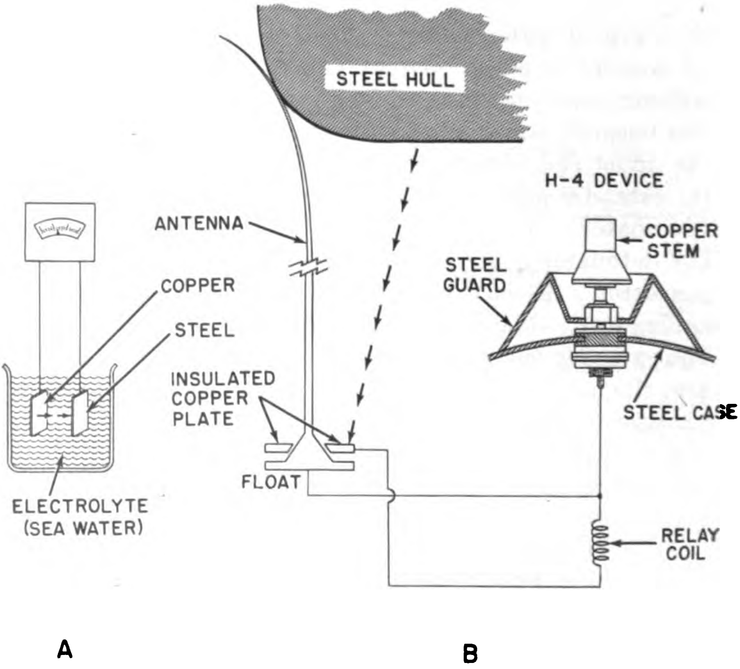


Figure 9-14.—Principle of the sea battery.

two electrodes and an electrolyte. The electrodes are respectively of copper and steel, and the electrolyte is the sea water surrounding the mine. As you can see by figure 9–14, *A*, two dissimilar metals and an electrolyte are all you need to have a battery that will actually produce current.

In the mine itself, however, the electrode arrangement (fig. 9–14, *B*) is a little different. Note that the antenna circuit consists of the copper antenna, a relay coil, and an insulated copper plate. The H-4 device has an insulated copper stem (also connected to the relay coil) surrounded by a steel guard.

Let's take up the antenna circuit first. In the absence of a steel hull in contact with the antenna, no current can flow in the circuit because the electrode at the opposite end of the circuit from the copper antenna is the insulated copper plate at its base. But let a steel hull touch the antenna: you then have your dissimilar metal for the other electrode, and current flows to the copper plate through the sea from the hull, through the relay coil, and back through the antenna in contact with the hull. This is called GALVANIC ACTION. The current produced by galvanic action isn't enough to heat up the detonator bridge wire, but it is enough to operate a relay which closes the interior (dry cell) circuit, which puts out enough juice to initiate the detonator.

A wooden hull will not detonate the mine through the antenna, but it (or any other kind of hull) can operate the H–4 mechanism by impact with the H–4's slender copper stem. The stem bends easily, and when it bends far enough to touch the steel guard around it, the steel mine case itself becomes the second electrode, and current goes through the relay coil to energize the interior circuit and blow up the works.

Let's go on to consider briefly other types of mines.

Ground Magnetic Mines

Every steel ship has definite magnetic characteristics produced by the permanent magnetism of the ship's hull and induced magnetism resulting from passage through the earth's magnetic field. A ship's magnetic field may be reduced substantially by using DEGAUSSING coils around the hull and by the process of DEPERMING (neutralizing the permanent magnetism of a ship), but it is impossible to eliminate such fields entirely.

The Mk 18 mine (fig. 9–15) rests on the ocean floor and is exploded by the magnetism of a passing ship. Unlike most newer types of magnetic mines, which are planted by aircraft, it is planted by surface craft. At depths of 35 to 150 feet, it is effective against surface vessels, and is planted down to 500 feet for use against submerged submarines.

The Mk 18 mine is launched in the usual way—by rolling it on tracks until it goes over the stern. The wheels are mounted on a rectangular unit under the cylindrical case. The wooden drag plate, attached by a rope, serves to pull the mine upright after it tumbles into the water. This is important, because the firing mechanism works best when the search coil is vertical. When the mine reaches a depth of about 30 feet, a release mechanism casts loose the drag plate, so that water currents striking the plate will not tip the mine over. Figure 9–15 shows what happens to the drag plate as the mine starts to sink and after the mine has reached the ocean floor.

Arming of the mine is controlled by an EXTENDER, and by a CLOCK DELAY MECHANISM. After soluble washers have dissolved, hydrostatic pressure causes the extender to move an electric detonator into the booster pocket, and also starts the clock. Switches controlled by the clock delay mechanism cause the mine to arm after the clock has run about 45 minutes.

Now the mine, resting on the bottom, is fully armed, with its search coil ready to detect the magnetic field of any ship that comes near. When a ship approaches, the ship's magnetism induces a voltage in the coil (hence this is an INDUCTION-type mine). The effect of this voltage is to set off a series of operations which quickly culminate in detonation of the main charge.

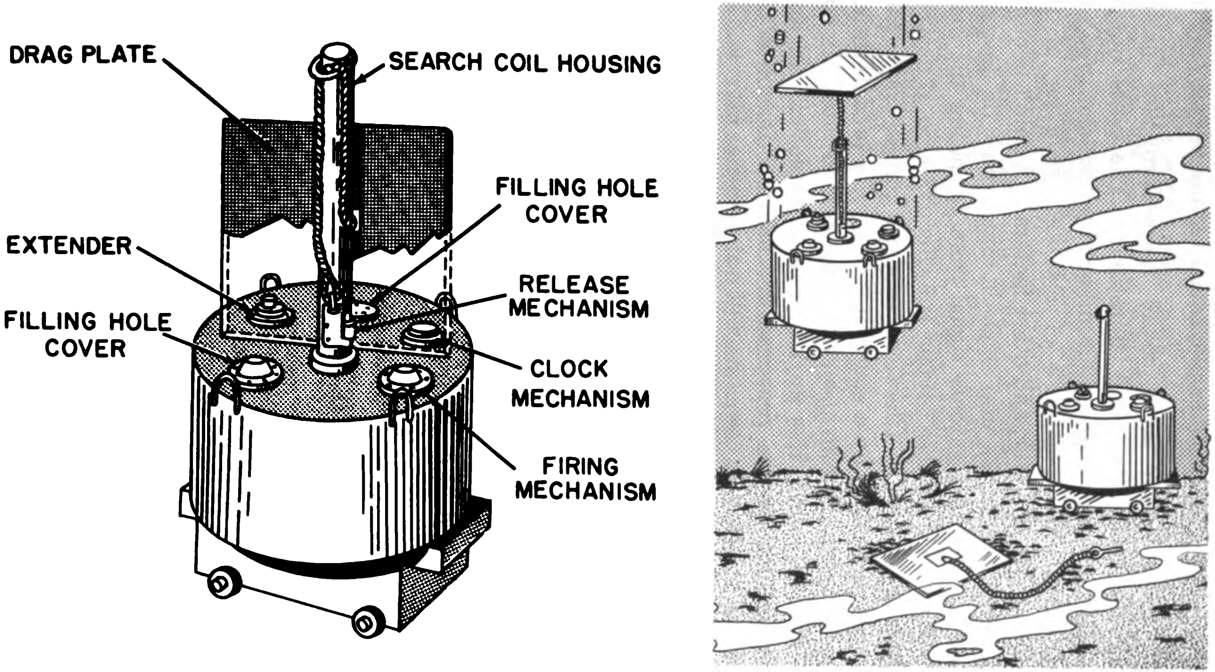


Figure 9-15.—Mk 18 mine assembly.

Acoustic Mines

All power-driven ships make noise—propeller noises, machinery noises, and hull vibrations. The noise output depends upon size, type, and number of propellers, type and speed of engines, condition of loading, character of the bottom, depth of water, and other factors. A ship's acoustic signal therefore varies, and acoustic mines must be designed to prevent a sudden intense signal from actuating the firing mechanism at distances beyond the effective area of destruction of the charge. Therefore acoustic mines are usually designed to be fired by a sound intensity of a predetermined value, after building up at a certain prescribed rate. In case of a sudden sound, like an underwater explosion, an anti-countermining device prevents detonation. If the sound builds up too slowly, the mine will not go off at all.

The Mk 13 Mod 6 mine (not illustrated here) is an older type of acoustic mine, planted at depths of 40 to 100 feet for use against surface vessels, and down to 500 feet for use against submerged submarines. It is designed to be dropped by aircraft.

This mine weighs about 1,020 pounds (TNT-loaded). It is carried in any aircraft that is fitted with racks or stations which will take general-purpose 1,000-pound AN–M44 or AN–M65 bombs, or in modified aerial torpedo racks.

Minesweeping

What goes down into the sea may have to be swept up—if it's a mine.

Moored mines are swept by means of a PARAVANE RIG. A paravane is most easily described as an underwater kite, towed by the minesweeper and secured to it by sweep cables. The sweep cable contacts the mine anchor cable, guiding it into the cutter jaws of the paravane. These jaws cut the mine adrift, allowing it to rise and be destroyed harmlessly on the surface.

Magnetic mines are swept by towing a buoyed electric cable over them. The strong magnetic field set up by this cable causes the mines to detonate. Because these mines are designed to function as the peak of the magnetic field passes, they are not set off by the relatively weak field of the minesweeper.

Acoustic mines are swept by creating underwater sounds of proper intensity and quality to actuate the mine firing mechanism. Noisemakers are of various types, some being towed astern by a sweep wire, others being located in the bow of the minesweeper to direct the noises ahead of the vessel. As yet the sweeping of pressure mines and subsonic acoustic mines has presented great difficulties.

CONCLUSION

In this chapter we have surveyed two types of weapons that are very important in our Navy's arsenal. Now that you have finished reading the chapter, you are by no means an expert, but you know something about bombs and mines. The knowledge will stand you in good stead when you work with Minemen and AO personnel.

QUIZ

1. A bomb consists of four principal parts. Name them.

In each of the following, select the BEST answer.

2. The function of the arming wires on a GP bomb is to
   a. keep the fuze armed
   b. prevent the arming vanes from rotating
   c. keep the fuze from being disarmed after it strikes the target
   d. connect the fuze to the detonator for electrical operation
3. The base plug in a bomb is threaded to receive the
   a. tail lock nut
   b. nose fuze
   c. arming wire
   d. suspension lugs
4. The loading factor of a bomb is the ratio of the
   a. weight of explosive to the weight of the case
   b. weight of explosive to the total bomb weight
   c. weight of the case to the total bomb weight
   d. power of the explosive to the thickness of the case
5. Bomb displacement gear on a dive bomber engages the bomb by its
   a. suspension lugs
   b. hoisting lugs
   c. boosters
   d. trunnions

6. In the typical bomb explosive train, the firing pin initiates the detonation by setting off the

   a. booster
   b. auxiliary booster
   c. detonator
   d. primer

7. The primer and detonator in tail fuzes equipped for delay firing are mounted in a separate piece screwed into the base of the fuze. This piece is called the

   a. booster
   b. Fahnestock clip
   c. retainer hook
   d. primer-det

8. In a VT fuze, current for the receiving and transmitting unit is provided by the

   a. battery
   b. generator on the high-speed shaft
   c. firing condenser
   d. detonator rotor on the low speed shaft

9. The reason for introducing a delay into an impact fuze is that it

   a. improves fragmentation of the case
   b. increases burster charge sensitivity
   c. permits piercing of armor
   d. ensures burster detonation

10. Which of the following types of aircraft bombs has the HIGHEST loading factor?

    a. SAP
    b. AP
    c. Frag
    d. GP

11. Depth bombs designed for launching by heavier-than-air craft are made with flat noses in order to

    a. reduce shock to the burster charge
    b. prevent ricochet on striking the water
    c. improve bomb fuze functioning
    d. penetrate greater thicknesses of armor

12. Thermate is made of

    a. jellied gasoline
    b. magnesium
    c. a mixture of aluminum powder and iron oxide
    d. a mixture of gasoline, napalm, and rubber cement

13. Which of the following is NOT a good safety practice for aircraft bomb handling or stowage?

    a. To prevent errors, bomb fuzes should always be stowed with the bombs in which they are to be installed
    b. Standard Army bomb fuzes should never be oiled or cleaned
    c. Always use the proper carrier when stowing or moving bombs
    d. Bombs should be stowed where they will be protected from excessive heat and sunlight

14. The "oscillating" mine is a type of
- a. ground mine
- b. controlled mine
- c. drifting mine
- d. moored mine

15. Soluble washers are used in mines to
- a. delay the arming of hydrostatic mechanisms
- b. start the functioning of clock starters
- c. keep electric firing circuits open
- d. sterilize the mine after a certain number of ships have passed near the mine

16. A steel-hulled ship will actuate a Mk 6 mine mechanism when it strikes the antenna because of
- a. breaking an acid vial in the mine
- b. magnetic action
- c. mechanical action
- d. galvanic action

17. The current in the Mk 6 mine's detonator bridge wire is supplied by the
- a. sea battery
- b. dry cell battery
- c. induction coil
- d. antenna

18. The paravane is used in sweeping
- a. ground mines
- b. pressure mines
- c. acoustic mines
- d. moored mines

CHAPTER 10

ORDNANCE SUPPLY

INTRODUCTION

Prior to World War II the Navy had no central system for procuring and distributing the material needed by the Fleet. Actually, there was little need for such a system. The Fleet was small; its needs were equally small. When an item was needed, it was bought directly from a manufacturer or made within the Navy.

The problem of supplying a modern Navy during the war pointed the way to the enormous and complex supply system we have today.

As the job of supply has expanded, the amount of paper work necessary to control its operation has mounted. Without records and reports it would be impossible to anticipate the needs of the Navy and to keep supplies moving from the factories to the consumer—in this case your own ship. The Bureau of Ordnance depends on your records, reports, and orders to supply you with ordnance material, and to GET IT TO YOU WHEN NEEDED.

Your Job in Supply

This chapter outlines your functions with regard to supply and tells you in a general way what you have to know to do this part of your job. Remember, though, that organizations differ and things change. Your ship may have a slightly different method of doing things to fit its own needs. Too, reports are constantly being revised. It is up to you to keep advised of these changes when they occur.

As a Gunner's Mate First Class or Chief you will probably be the senior man in charge of maintenance and operation in your division. You will therefore be responsible for maintaining and replenishing the stocks required for this purpose, for helping to plan for future needs, and for reporting on the status of those stocks. These, in general, are your main responsibilities with regard to supply.

Supply Paper Work

The paper work you will be expected to do in connection with these responsibilities include, briefly, the following:

1. You must know how to draw material from stores, using the appropriate forms.
2. You must supervise the inventorying of and accounting for your stores and repair parts, including issues and receipts. This calls for a knowledge of ordnance inventory control forms and reports, and of supply channels.
3. You must know the reports required by the gunnery department and how to prepare them. This chapter takes up only those concerned with supply. Chapters 2 and 5 contain information on other reports and records required in your job. Instructions from the Bureau of Ordnance, the Ordnance Supply Office, and the Bureau of Supplies and Accounts will keep you abreast of the latest information.

All this paper work may not seem as urgent to you as some of your other duties, but it is important. The thing to remember is to keep your paper work UP TO DATE and to keep it ACCURATE. Once you get behind with the paper work required of you, it may be extremely difficult to catch up.

Navy Supply System

Before we take a look at some of the actual paper work jobs you will be performing, let's examine briefly the Navy supply system especially with regard to ordnance supply.

Specific and detailed information on Navy supply is contained in the *Bureau of Supplies and Accounts Manual.* This manual, which is made up of several loose-leaf blue-bound volumes, is BuSandA's operational guide for personnel in charge of each phase of the receipt and expenditure of the Navy's public funds and property. If you have any question about supply, ten to one the answer is in the *BuSandA Manual.* But because this set of books is intended more as a reference for the expert than as an introduction for the novice, let's take up the Navy's supply system in simpler terms.

The supply system can become very complicated if you let yourself get lost in the details. There is nothing simple about Navy supply. But this chapter can tell you, to the extent that you, as a non-specialist in supply, need to know it—

1. Who is responsible for supply.
2. Terms used in supply.
3. How to identify the things you need.
4. How to get them from supply sources.
5. Who is responsible for material after it is received.
6. How to draw material from stores.
7. Some records you keep concerning material.
8. Who stores the material and how.

RESPONSIBILITY FOR SUPPLY

The Bureau of Supplies and Accounts (BuSandA) is the Navy's organization for determining policies and outlining the procedure to be followed in performing supply and fiscal functions both afloat and ashore.

The commander in chief of a fleet is responsible for supply afloat. One of his major duties is that of directing the general over-all policies and general logistics plans for the supply of the fleet and shore activities of the area.

The commander, service force, in turn, is responsible for advising fleet, force, and type commanders on matters of supply, including supply sources and availability of funds and material.

On your ship, supply responsibilities rest with the commanding officer, who, in turn, delegates them to your supply officer.

Bureau of Ordnance

Where does the Bureau of Ordnance fit into this supply picture? The Bureau of Ordnance is responsible for procuring your ship's armament, ordnance equipage, tools, repair parts, and accessories. In your job you will be guided by publications and directives put out by both BuOrd and BuSandA.

Ordnance Supply Office

While the Bureau of Ordnance is the agency that purchases ordnance material, it delegates much of the duty of distribution of the material (other than ammunition) to the ORDNANCE SUPPLY OFFICE (OSO). OSO is charged with distributing ordnance repair parts, tools, and accessories. In addition, this office prepares and issues your ordnance allowance lists.

TERMS USED IN SUPPLY

Before we go further, let's look at some of the terms used in the supply system vocabulary and their definitions as applied to Navy supply.

These definitions may not conform with various local interpretations employed by activities not engaged in supply. They are, however, the accepted interpretations for ordnance identification. Their use will ensure a common technical language for supply operation.

MATERIAL is the term used to describe all the items listed in the *Catalog of Navy Material*, including all its special sections such as the BuOrd Section. (More on this catalog later.) Navy material includes SUPPLIES, REPAIR PARTS, and EQUIPMENT. It does NOT include ammunition for guns, rockets, or A/S projectors.

CONSUMABLE ITEMS are those used up in the course of upkeep operations.

NONCONSUMABLE ITEMS are those which are ordinarily usable over a long period.

SUPPLIES is the general term used to designate operating and maintenance material consumed in use. As you will note in the next paragraph, supplies do not include repair parts for nonconsumable equipment.

REPAIR PARTS are items which can be used to replace parts unfit for further use in nonconsumable equipment.

Repair parts intended for use in guns of all calibers, gun installations, fire control equipment, rocket launchers, projectors, small arms, torpedoes, and depth charges, with all the launching and storing equipment usually associated with them, are called ORDNANCE SPARES. (The term does not apply to rocket or gun ammunition, ammunition details, ammunition containers, explosives, or pyrotechnics.)

EQUIPAGE is the term used to identify assemblies not consumed or appreciably altered in use, and usually of greater functional importance and value than supplies.

ORDNANCE EQUIPAGE is any material designated as such by the Bureau of Ordnance. A complete list of items which BuOrd considers equipage is found in volume 2, chapter 2, of the *BuSandA Manual.* As a Gunner's Mate you will be particularly interested in the sections of the list headed "Gun and Mount Material" and "Small Arms, Infantry Equipment, and Miscellaneous."

> NOTE. The asterisks beside some of the items in the list indicate that custody signatures are not required. (More on custody signatures later in this chapter.)

DRAWING NUMBER. The drawing number is the number assigned to the blueprint plan of an ordnance component or assembly. This number can be used to identify the item.

PIECE NUMBER. The piece number is a subdivision of the drawing number. Every item appearing on any drawing that shows more than one piece or assembly has a piece number to identify it.

In addition to these two numbers, some ordnance equipment may have a SERIAL NUMBER which gives individual identity to units that are alike in physical make-up. This number is stamped into the equipment and is used to make identification of the manufacturer easier and to place responsibility for custody.

IDENTIFYING THE THINGS YOU NEED

To order material and to assure receipt of it by your division, you make out a REQUISITION. But, to be sure you receive them, you have to do more than merely list on a requisition form the names of the items you want.

There are thousands of pieces of equipment, repair parts, and supplies available through the Navy supply system. There would be too much chance for confusion if you stated on the requisition only that you wanted a WRENCH, or perhaps a 5/16-inch SCREW. What kind of wrench? Open end? Pipe? Hex key? Face spanner? What kind of screw? Flat head? Socket head? You see the problems raised when items are not COMPLETELY identified.

This section can help you identify what you want by (1) telling you why material is classified into numbered groups containing like items, (2) showing you how it is classified into those groups, and (3) listing some sources (particularly your allowance list and the BuOrd Section of the *Catalog of Navy Material*) you can use to obtain complete and proper identification of the item you want.

Why Material is Classified

Because of the great variety of different items carried in the Navy supply system, it is necessary to have a workable method of keeping order and control over procurement, inspection, storage, transportation, issuing of, and accounting for, supplies. In this system, numbers and letters are combined to obtain the STANDARD NAVY STOCK NUMBER used to identify each item.

Let's first take a look at this letter-number system as it applies to ordnance. The ordnance system is an expanded variation of the basic method used by the Navy for general stores material. (We will take up the general stores system later.)

Ordnance Stock Numbers

Stock numbers are normally made up of three elements. You will find occasional variations, but basically the system follows the pattern presented in the schematic below.

Cognizance symbol	Material class code	Identifying index
Letter	3-digit numbers	Identifying numbers

COGNIZANCE SYMBOL. A cognizance symbol is a letter code at the front of the stock number to show which bureau, office, or other activity has inventory control over the material. The two cognizance symbols you will be using most are *J* and *Z*. The *J* indicates that the item is controlled by the Bureau of Ordnance and *Z* indicates Ordnance Supply Office control.

MATERIAL CLASS CODE. Naval ordnance material is segregated into numbered classes. Each 3-digit class represents a particular type of material, such as guns, underwater ordnance, fire control equipment, and so forth. Most ordnance material will be found in classes 010–049, 740, 950–959, 960–969, 970–979, and 990–999. As you will see later, the third digit in each class often represents a further breakdown or subclass.

IDENTIFYING INDEX. The remaining portion of the stock number consists of an identifying number, such as a drawing number, list sketch number, NavOrd list number, Army number, or manufacturer's number. You can think of this final portion as pinning the entire classification down to a specific item.

To illustrate, let's look at a standard Navy stock number used to requisition an ordnance item, and then break down its various portions.

The stock number to be used for requisitioning the HOIST CHAIN ASSEMBLY for the Mk 4 twin projectile hoist (for 5-inch mount) is Z012–237043–1. At this point you can no doubt recognize the three elements mentioned above, and if you filled in the blocks in the schematic, you would have something like this:

Cognizance symbol	Material class code	Identifying index
Z	012	237043–1

But let's be even more specific. To go into each part of the stock number, let's look at the following table:

Z012–237043–1	"Z" indicates Ordnance Supply Office (OSO) cognizance.
Z012–237043–1	010–019 is the material class code for guns 3-inch and larger, missile launchers, and associated equipment. The third digit (2) in this number is the subclass or breakdown indicating guns and mounts 5-inch to 5.9-inch inclusive.
Z012–***237043***–1	Indicates the drawing number.
Z012–237043–***1***	Indicates the piece number.

General Stores Stock Numbers

Some items you will be using, such as bolts, nuts, screws, and so forth, are not peculiar to ordnance. In other words, they are items used by two or more bureaus of the Navy. This makes them GENERAL STORES material. They are listed in the General Stores Section, *Catalog of Navy Material.* As mentioned earlier, the stock numbering system used to identify such material differs from the ordnance method, particularly in the numbering portion indicating the stock class.

A stock number for general stores material will contain three elements we found in ordnance material: (1) a cognizance symbol, (2) a portion using numbers to represent the class of material, and (3) an identifying index.

A word here about the cognizance symbol. As a rule, items of a general stores nature, that is, items in use in several bureaus, are controlled by the General Stores Supply Office and will have a *G* for a cognizance symbol. However, don't be confused if a stock number for a screw carries a "J" or "Z" cognizance symbol. In this case it indicates that the item, although of a general stores nature, is one that will be used on a specific piece of ordnance equipment and is therefore controlled by BuOrd or OSO.

After the cognizance symbol comes a 2-digit numbering portion indicating the class of material. This portion is called the stock class. After the stock class (which we could compare to the material class code) comes the identifying index. The first part of the index may contain a letter. This is the first letter of the name of the item; for example, *B* for Bolt, *W* for Washer, and so forth. The remaining portion of the identifying index is made up of a "serial number" giving individual identity to the item.

Let's use the schematic again to illustrate.

Cognizance symbol	Stock class	Identifying index	
Letter	2-digit numbers	Letter	Identifying numbers

Now we can take up a specific item of a general stores nature and apply what we have learned from the schematic to analyze its parts.

The screws required for the cover of the hand access hole on the column of a 5-inch projectile hoist have been assigned stock number Z43–S–13646.

We now know how to recognize the three major elements of a stock number. Filling in our diagram, we would have the number broken down as shown on page 393.

The "*Z*" indicates the item is under OSO cognizance; *43* is the stock class for screws, "*S*" is the initial letter of the name of the item; and the remaining portion pins down a specific type and size—in this case, a ¼-inch machine screw.

Cognizance symbol	Stock class	Identifying index	
Z	43	S	13646

Since the secret of obtaining the right repair part when you need it is highly dependent on how accurately you can identify it in the requisition, let's briefly review what we have learned about identifying ordnance and general stores items.

First, we know that the combination of letters and numbers used to identify ordnance material is a variation of the system used for general Navy material. We know that a specific item in either category will usually have the following elements: a cognizance symbol, a numbering portion representing a particular class of material, and, finally, a portion containing other numbers pinning the entire classification down to a specific item. We have learned that the numbering portion indicating the class of material has three digits for ordnance items and is called a material class code; for general stores material, the portion is called a stock class and contains two digits. And, for items of a general stores nature, we will usually find a letter in the identifying index indicating the initial letter of the name of the item.

Keep in mind the fact that you will find variations in the stock numbering system; also don't be stumped when you find an item for which no stock number is given.

The problem of assigning stock numbers to every item in the supply system is immense. The stock numbering plan is a comparatively recent development. Thousands of items already in the supply channels still have no stock number in the system just described. So, use the stock number if you can, but when you find that no stock number is available for an item, use the identifying number (usually the drawing or piece number) assigned to it.

The next section takes up publications in which the stock number or other identifying number will be found.

The limited scope of this chapter does not permit a more detailed analysis of stock numbers. Further information may be found in chapter 2, volume 3, of the *BuSandA Manual*.

Allowance Lists

You have seen why it is necessary to be specific in naming and identifying items, and you have learned something of the methods used to assure correct identification. Now, let's discuss some of the sources you can use to obtain the necessary information.

Your ALLOWANCE LIST will be the source you will use most often to obtain the complete nomenclature and stock number. In addition, you will use the list to prepare custody and stock cards.

Your ship is required to carry a full allowance of ordnance equipage and repair parts and is not permitted to exceed that allowance without Bureau approval.

So that you can determine just what equipment is needed for efficient operation and maintenance of your department, the Bureau of Ordnance issues NavOrd lists. Each NavOrd list is made up for a different type of equipment, such as 5″/38 caliber guns, small arms, landing force equipment, and so forth. The complete file of applicable NavOrd lists aboard your ship makes up your ALLOWANCE LIST. This allowance list both identifies the equipment and prescribes the number of units of each item assigned to your ship.

NavOrd lists are prepared by the Ordnance Supply Office under the direction of BuOrd. Two copies of each NavOrd list required are issued to each ship. One complete set making up your allowance list will usually be kept by your department head and the other by the supply officer.

For a particular type of equipment within your allowance, you will find the following information on the applicable NavOrd list:

1. Identification of the basic equipment, with mark and mod numbers or stock number (if any), and drawing and piece number.

2. Lists of repair parts, tools, accessories, and supplies that make up one full set of repair parts for the various components of the equipment.
3. A key showing how many full sets of material are required, depending on how many units of the equipment are installed aboard.

NavOrd lists also indicate ammunition allowances (per barrel) for peacetime and war readiness conditions. These allowances may be modified by instructions issued by the type commander or other competent authority.

The NavOrd lists that make up your allowance list are constantly being revised to include the latest changes and additions. It is very important that you always refer to the latest list aboard when you order material.

To help ensure that you have a COMPLETE file of NavOrd lists aboard your ship, and that the file is UP TO DATE, OSO makes up and distributes two indexes of NavOrd lists.

The first index you use to make sure that your NavOrd list file is complete. It is printed by electrical accounting machines, and lists alphabetically all the ships in the Navy (in both the active and reserve fleets). For each ship it shows all the NavOrd lists that should be aboard. Ordnance Supply Office calls this electrical accounting machine list "NavOrd List 00" (double zero), and that's how you should order it if for some reason your ship lacks it. It is revised annually. By the way, the complete index comes in 17 volumes, but all that your ship receives are the specific pages that apply to it.

The second index is NavOrd List 0 (single zero). You use it to make sure that the NavOrd lists you do have are up to date. OSO revises NavOrd lists by issuing new pages which you insert into your NavOrd list file to take the place of obsolete pages. NavOrd List 0 shows for each NavOrd list what pages should be in it.

Let's look into a typical NavOrd list and see how it is made up.

NavOrd List No. 23145, which we will use as an example, is for 5"/38 caliber twin mounts, Mk 28 and Mods, Mk 32 and

Mods, and Mk 38 and Mods. This publication is indexed by sections: Section A for Accessories; Section B for Carriages, and so forth.

Items in a typical section, for example that for TRAINING GEAR (Section D), are broken down under subheads such as "Worm and Pinion Bracket Assembly," "Repair Parts for all Marks and Mods," "General Stores Type Material," and "General Stores Material."

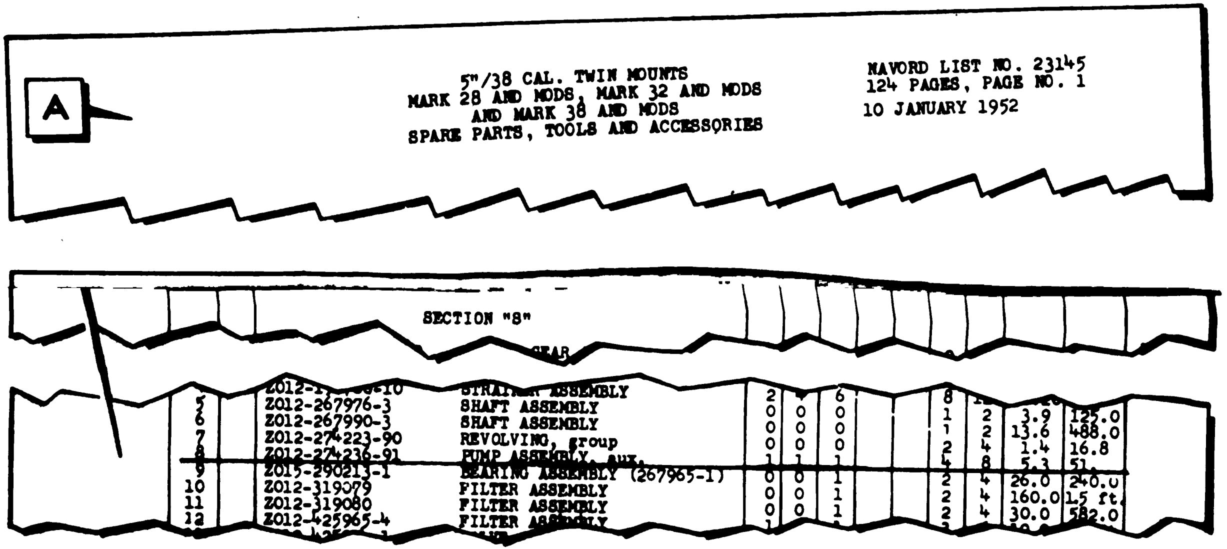
At the end of each section is a table giving the weight and cubic volume of a complete set of items. This table is used in connection with the key which shows how many full sets of material are required.

Let's pick an item at random, enter our list, and see what information is given. As you read the explanation below, refer to figure 10–1 for a step-by-step illustration of the process.

Suppose you are serving aboard a light cruiser and the auxiliary pump for the train power drive on your No. 51 mount goes out on you. Let's see what you find in the NavOrd list about this pump. (Fig. 10–1, *A*.)

We know it is part of the hydraulic train power drive; so we enter the index of the list (fig. 10–1, *B*) and find that Elevation and Training Gear, Hydraulic Power Drives, will be in Section S, pages 67–77. (Fig. 10–1, *C*.) Turning to page 67, we find the pump listed as item 8 on the page. (Fig. 10–1, *D*.) At the top of the page is the key you use to determine just how many pumps you are allowed to keep on board as spares. Since your ship falls in the "4 to 6 Mount Installation," you will use column 2. Under column 2 you will find that your ship is allowed to carry one pump as a spare. You can now draw your spare pump and install it.

But the usefulness of the list does not end at this point. You now have to requisition another to replace the one installed. Let's look again at our list. All the information needed to prepare the requisition is there. Moreover, the list constitutes your authority to draw the unit to replenish your stock. We will take up requisitions later, but at this point you should make a note of the fact that your requisi-



5"/38 CAL. TWIN MOUNTS
MARK 28 AND MODS, MARK 32 AND MODS
AND MARK 38 AND MODS
SPARE PARTS, TOOLS AND ACCESSORIES

NAVORD LIST NO. 23145
124 PAGES, PAGE NO. 1
10 JANUARY 1952

SECTION "8"

GEAR

	Z012-1[illegible]-10	STRAINER ASSEMBLY	2		6	8		
5	Z012-267976-3	SHAFT ASSEMBLY	0	0	0	1	2	3.9	125.0
6	Z012-267990-3	SHAFT ASSEMBLY	0	0	0	1	2	13.6	488.0
7	Z012-274223-90	REVOLVING, group	0	0	0	2	4	1.4	16.8
8	~~Z012-274236-91~~	~~PUMP ASSEMBLY, aux.~~	1	1	1	4	8	5.3	51.
9	Z015-290213-1	BEARING ASSEMBLY (267965-1)	0	0	1	2	4	26.0	240.0
10	Z012-319079	FILTER ASSEMBLY	0	0	1	2	4	160.0	1.5 ft.
11	Z012-319080	FILTER ASSEMBLY	0	0	1	2	4	30.0	582.0
12	Z012-425965-4	FILTER ASSEMBLY							

Figure 10-1.—Typical NavOrd list

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tion form for this item will contain the list number, 23145; page number, 67; section, S; and stock number, Z012-274236-91.

Bureau of Ordnance Section—Catalog of Navy Material

Ranking with the allowance list as a source of information for identifying items is the BUORD SECTION of the *Catalog of Navy Material.*

Let's imagine that one of the training handwheels on our 5″ twin mount has broken. Since this is a rare occurrence, there is probably no extra carried as a repair part. In that case, it won't be on your allowance list. Here's where the BuOrd part of the catalog comes in handy. You find in the catalog the assembly or group of which the handwheel is a part. There you will see it illustrated, and identified by drawing number, stock number, and nomenclature. With this information you can make up a requisition to obtain a replacement.

The Ordnance Catalog is arranged in a system known as "topdown breakdown." Each major equipment is listed by section to show—

1. What major components (housing, stand, mechanism, etc.) go to make up the complete equipment.
2. Assemblies and groups comprising the major components.
3. Parts making up the assemblies.

Parts are systematically grouped to show their common usage within assemblies and subassemblies.

Along with this, the catalog is illustrated. The isometric and exploded view illustrations are designed to conform as accurately as possible to the actual breakdown of the equipment.

Each Ordnance Catalog section consists of

1. A four-digit section number (4132, 5236, etc.). (This number is used for indexing purposes only. Do NOT use it for identifying equipment.)
2. Foreword: This contains information on how to use the catalog, how to order, and so on. Read the Foreword

carefully; catalog arrangements vary from one equipment to another.

3. Major Breakdown Table (given only for large equipments like gun mounts).
4. Assembly Index.
5. Component Breakdown Table. This is the portion of the Catalog that contains listings and illustrations of assemblies, subassemblies, and parts, in relation to the complete equipment.
6. Alphabetical Listing of Parts. This is very useful in locating parts when only the NAME of the part is known.
7. Numerical Listing. This is possibly the most used part of the entire Catalog. Every drawing number for each item in the equipment is listed here in numerical sequence along with the stock number (if one has been assigned). This is the listing to use for ascertaining stock numbers when you are ordering.

At present, a complete set of Bureau of Ordnance Catalogs is kept by your gunnery officer. (Eventually, only those parts of the catalog that apply to equipment actually aboard will be issued to ships.) When new or revised sections are printed they are automatically issued to your ship. As a further aid in maintaining a current catalog, refer to the Catalog Index. Order missing sections from the Ordnance Supply Office, Mechanicsburg, Pennsylvania.

GETTING MATERIAL FROM SUPPLY SOURCES

One of your responsibilities is to get the material you need. As a rule, the supply officer will procure it, provided you furnish him with the necessary information. He is responsible for procuring such articles as landing force equipment, small arms, and repair parts. But he is NOT responsible for procuring INSTALLED ORDNANCE EQUIPMENT and AMMUNITION.

Procurement by Letters of Request

All fixed installations of ordnance equipment on newly commissioned ships are installed under the direct cognizance of BuOrd, and remains under its cognizance. If the gunnery officer desires to install an item in this category, the equipment is obtained through a LETTER OF REQUEST from your commanding officer to the Bureau of Ordnance.

Ammunition, ammunition details, components, and accessories are also obtained by letters of request from your commanding officer. He sends a letter requesting these items to the commanding officer of the appropriate ammunition-issuing activity.

On most ships, letters of request normally are prepared by the gunnery officer, but you will be responsible for supplying the information as to the kind and quantity of items needed. The form of the letter will follow the current BuOrd procedure.

When your ship requests ammunition, the following information will be given to the issuing activity:

1. The mark, mod, type, and actual number and caliber of guns, projectors, launchers, bomb racks, weapons, and so forth on board in which the ammunition will be used; and the type and number of assigned landing craft, lifeboats, life rafts, and other units for which ammunition is required.
2. The quantity and description of the ammunition required.
3. The time and place delivery is desired. As much advance notice as possible is given the issuing activity in order that arrangements may be made to provide ammunition not in stock.

Procurement by Requisition

We have seen how material is obtained by letter of request directly through BuOrd. Now let's look into the procedure of obtaining material through your supply officer, by requisition.

REQUISITIONS are written requests of your ship for material or services from another naval activity. They are prepared by your supply officer (except for those items over which he has no control), but it will be up to you to furnish the correct information.

All items of portable ordnance material, such as repair parts, small arms, landing force equipment, and so forth, are requisitioned by the supply officer on Requisition and Invoice Form (SandA Form 43) for material not in excess (see fig. 10–2); or on Requisition Afloat: In-Excess Material (SandA Form 44) for material that is in excess of your allowance.

In-Excess and Not-in-Excess

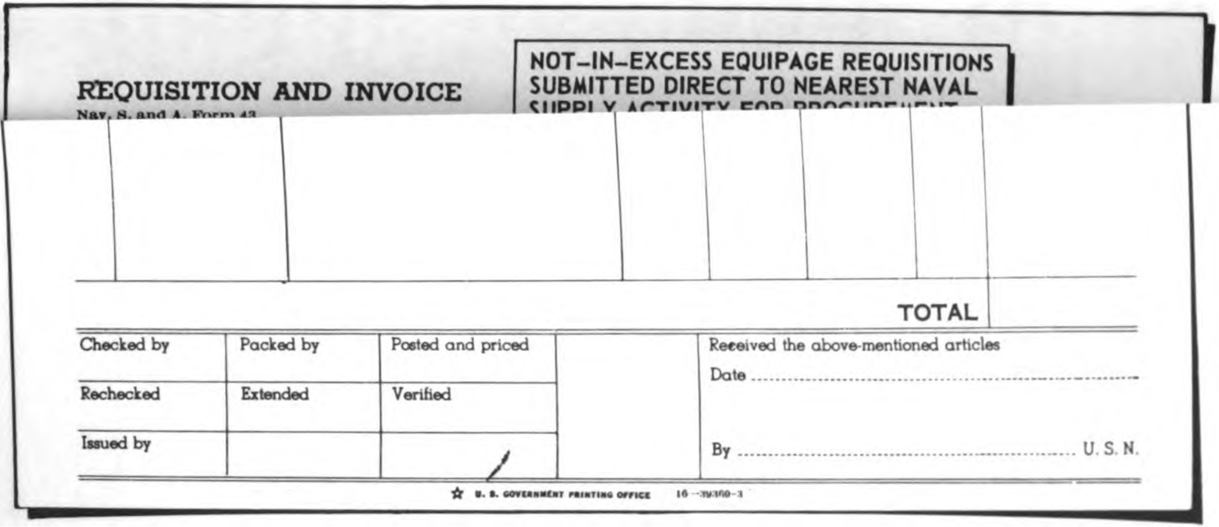
Here is how you can tell whether material should be listed on a not-in-excess requisition or on an in-excess requisition.

NOT-IN-EXCESS REQUISITIONS may list—

1. Equipage on a ship's allowance list not in greater quantity than is necessary to bring the amount on hand and on order up to full allowance. Example: If your allowance list says you are supposed to have 6 units and you have 2, you can requisition up to 4 additional units in this way.
2. Consumable supplies listed in the *Catalog of Navy Material* or your allowance lists.
3. Items which may be substituted for those on the allowance list.
4. Material either required for immediate use in repairs or alterations, or to replace the material used in the repairs or alterations.

IN-EXCESS REQUISITIONS may list—

1. Equipage NOT on your allowance lists.
2. Equipage on the allowance list but in greater quantities than the list allows. Example: Your allowance list says you are entitled to 6, and you have 6, but for good and sufficient reasons you want 8, so you requisition 2 more.
3. Consumable supplies not on the allowance lists, not standard stock, and which you will not use for the same purpose as you would use a comparable item given on your allowance list or in the *Catalog of Navy Material*.



REQUISITION AND INVOICE
Nav. S. and A. Form 43

NOT–IN–EXCESS EQUIPAGE REQUISITIONS
SUBMITTED DIRECT TO NEAREST NAVAL

TOTAL

Checked by	Packed by	Posted and priced		Received the above-mentioned articles Date ....
Rechecked	Extended	Verified		
Issued by				By .... U. S. N.

☆ U. S. GOVERNMENT PRINTING OFFICE 16—39350-1

Figure 10–2.—Requisition and Invoice form (SandA Form 43) for material not-in-excess.

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When you submit a not-in-excess requisition, the signatures of your department head and the supply officer are all the approval needed.

In-excess requisitions must be approved by the commanding officer and then submitted to the responsible bureau via the type commander. Except in an emergency, your ship can't take any steps to procure such material UNTIL the cognizant bureau has approved the request. Emergency procedure is outlined in paragraph 33022–3b of the *BuSandA Manual.*

Funds and Accounts

Since the taxpayers' dollars are used by the Navy to purchase the material, labor, and services aboard your ship, certain rules must be set up to ensure the economical use of these items. To do this, the Navy Department has an elaborate accounting system to keep track of all the expenditures it makes from Congressional appropriations.

As a Gunner's Mate, you will not need an extensive knowledge of this system, but you should know where the gunnery department fits in the picture. Therefore, let's take up two terms used in connection with naval accounting and apply them to the material you use.

APPROPRIATIONS PURCHASES ACCOUNT (APA).—For your purposes, think of APA as being an account in which is carried material paid for with BuOrd's annual appropriation from Navy Department funds.

As a rule, it is the nature of the material that determines whether BuOrd pays for it out of its own appropriation. Technical material designed for a specific purpose, such as a repair part for a 40 mm gun, could hardly be used for anything other than that gun, so BuOrd is willing to spend its own money for it.

Because it was paid for by BuOrd at the time it was placed in store, with few exceptions it is not charged to your ship when it is issued. As you see, financing APA items is primarily BuOrd's responsibility so you don't need to concern yourself with accounting practices for these items.

NSA items do affect your department's budget, so let's take up this system in more detail.

NAVY STOCK ACCOUNT (NSA).—NSA is an account for material of a general nature, such as paint, lubricants, common nuts and bolts, and so forth, used by more than one bureau. The money used to buy material that is placed in this account comes from a NAVY STOCK FUND. Think of the Navy Stock FUND as a convenience set up to provide the Navy with dollars to purchase such material, and the Navy Stock ACCOUNT as a place to hold the material until it is issued to an activity. There is nothing but money in the fund; nothing but material in the account. Material is "bought" from the account and the money for it is paid into the fund. We will see how this is done in just a moment.

We know that, in general, APA material is paid for by BuOrd and your ship doesn't have to pay the Bureau for it when it is issued. The procedure is somewhat different with NSA material. When this material is issued, the gunnery department must pay the Navy Stock Fund for it.

To explain this, let us go back to the source of all the money the Navy spends—the Congressional appropriation. The money used to finance the Navy's day-to-day operations is appropriated under the title "Ships and Facilities, Navy" (abbreviated S & FN). BuShips makes quarterly ALLOTMENTS of this money to each ship in the Fleet. The captain of each ship divides the ship's allotment, by means of a departmental budget, among the various departments of the ship, in accordance with the estimated needs of each department and the total amount of money available in the allotment. Thus, each department head of the ship knows how much money he will have available for the coming quarter, and plans his department's operations accordingly. The allotment can be expended not only for NSA materials, but also for civilian labor at naval shipyards, purchase of supplies ashore (in emergencies), transfer of supplies from other ships, and so on.

Up to this point, we have been discussing money. But when you take a requisition to the Storekeeper to get a can of paint so that your GM striker can paint the deck of No. 51 mount, you don't give the Storekeeper any money. Where does the material you draw from stores fit into the picture?

Here's how: A BuSandA agency buys and stores NSA material for the Navy, using money from the Navy Stock Fund. When the material is bought, it is placed in the Navy Stock Account.

Now the supply officer aboard your ship knows, through records of previous usage and the advice of other department heads, approximately what the needs of the ship will be under normal circumstances for the materials he stocks. Periodically, he replenishes the ship's supplies of NSA materials by requisition on Navy supply sources. These requisitions record not only the physical transfer of materials from warehouses and supply ships, but also expenditures of appropriate amounts from the ship's S & FN allotment to "purchase" the material. When the ship's supply officer requisitions paint, for example, from a Naval Supply Depot (NSD) ashore for general shipboard use, the amount of paint issued is deducted from the Navy Stock Account. At the same time, the Naval Supply Depot credits the Navy Stock Fund with the proper dollar value deducted from the ship's S & FN allotment to pay for the paint. The money in the Navy Stock Fund is then used to purchase supplies to replenish the Navy Stock Account.

So, then, when the gunnery department requisitions paint, to be applied to the deck of No. 51 mount, no money actually changes hands, but the supply officer deducts the cost of the paint from the gunnery department's quarterly allotment.

With a few exceptions, a good general rule you can apply to determine whether material is APA or NSA is this: If it has a "J" or "Z" cognizance symbol, it's APA; if it has a "G" cognizance symbol, consider it NSA.

As a Chief Gunner's Mate, you will find it handy to know these elements of this system and how to apply them, because you will be expected to help the gunnery officer in planning gunnery department operations and expenditures.

For further information on the Navy's accounting system, you should consult the *Navy Comptrollers Manual*, volume 2. (This book replaces volume 7 of the *BuSandA Manual*.) See your supply officer if you need to use it.

RESPONSIBILITY FOR MATERIAL

So far we have discussed how to find the item you want and how to get it by using allowance lists, catalogs, letters of request, and requisitions. The next step is RECEIVING the material you have ordered and ACCOUNTING for it.

The supply officer is responsible for the receipt of all ordnance material except expendable ammunition and ordnance equipment for permanent installation. (As you remember from the section on Letters of Request, this is the responsibility of the commanding officer.)

Custody of Ordnance Material

Once the material has been received, the supply officer assigns custody of the various items. Let's see how this affects your department.

In general, ordnance material is in the physical custody of the gunnery officer. The supply officer normally has custody of repair parts in order to control their issue and replenishment. However, if his storage space is limited, the commanding officer may decide to assign this responsibility to your department head. If he does, the authorization will be in writing.

If the supply officer keeps custody of the ordnance material he receives, he will assign it to the Storekeeper in charge. When the Storekeeper receives the material, chances are you will be asked to inspect the parts to determine whether or not they meet specifications and to be sure they are properly identified.

If your gunnery officer is to have custody, your department will, of course, inspect the material.

GETTING MATERIAL FROM STORE

The next step is to get the parts you want out of the storeroom.

When you need material and the supply officer has custody of it, you will use a Stub Requisition (SandA Form 307) signed by your department head to get it from store. Figure 10–3 shows Form 307 made out for several tools. When the form is made out for ordnance spare parts, it must contain, in addition—

1. The name of the equipment for which the part is required.
2. The complete nomenclature of the part.
3. The number and/or location of the equipment for which the part is required.

Parts for only one type of equipment are included on each stub requisition.

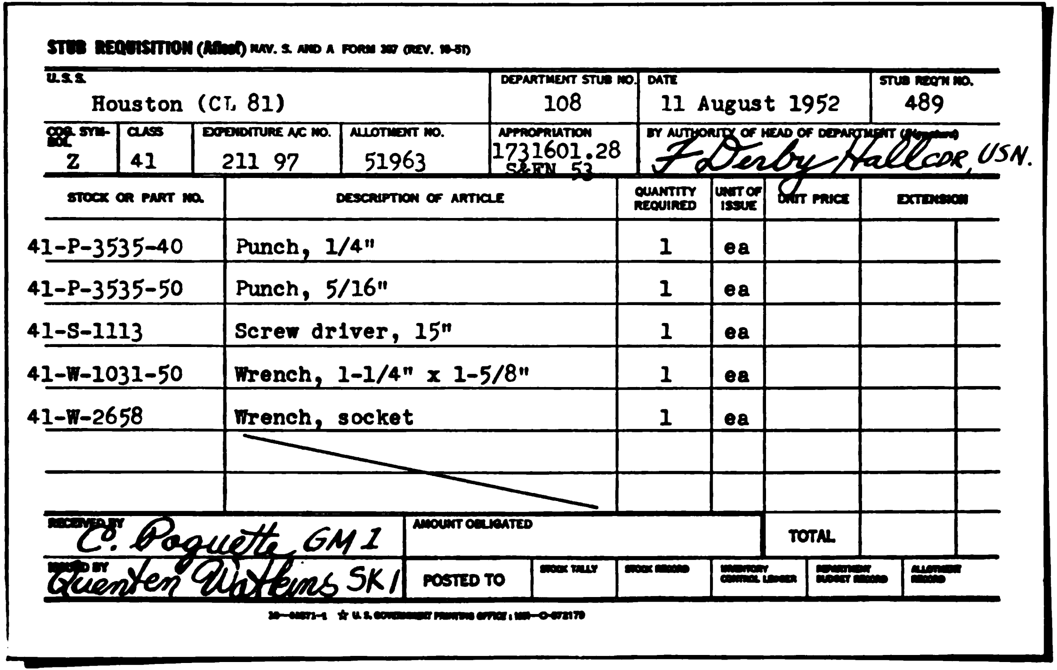
When the stub is properly prepared and signed, take it to the Storekeeper in charge of repair parts. He will check the stub to be sure you've given him all the information necessary for him to make out a REPLACEMENT REQUISITION. He will then issue the part and get your signature on the stub.

Processing a Stub Requisition

What happens to the stub requisition after you have turned it over to the Storekeeper and he has issued you the part? The Storekeeper marks the stub with the number of the repair parts box from which the part came. That number will appear on a replacement requisition when he makes it out. Next he assigns a serial number to your stub. This number identifies your department. Then he notes the issue of the part in a record book and files your stub, either in a separate file or in the box from which he took the part. He keeps the stub requisition until he can replace it with the replacement requisition for the issued parts.

Requisitioning from Gunnery Department Custody

If your department has custody of the repair parts, you still must use a stub requisition. Your department head must establish a system for issuing the parts he keeps in his custody. Each time a part is issued, the stub requisition



STUB REQUISITION (Afloat) NAV. S. AND A FORM 307 (REV. 10-51)

U.S.S. Houston (CL 81)				DEPARTMENT STUB NO. 108	DATE 11 August 1952	STUB REQ'N NO. 489
COG. SYMBOL Z	CLASS 41	EXPENDITURE A/C NO. 211 97	ALLOTMENT NO. 51963	APPROPRIATION 1731601.28 S&FN 53	BY AUTHORITY OF HEAD OF DEPARTMENT (Signature) F. Derby Hall CDR, USN.	

STOCK OR PART NO.	DESCRIPTION OF ARTICLE	QUANTITY REQUIRED	UNIT OF ISSUE	UNIT PRICE	EXTENSION
41-P-3535-40	Punch, 1/4"	1	ea		
41-P-3535-50	Punch, 5/16"	1	ea		
41-S-1113	Screw driver, 15"	1	ea		
41-W-1031-50	Wrench, 1-1/4" x 1-5/8"	1	ea		
41-W-2658	Wrench, socket	1	ea		

RECEIVED BY C. Poquette GM1	AMOUNT OBLIGATED				TOTAL	
ISSUED BY Quenten Watkins SK1	POSTED TO	STOCK TALLY	STOCK RECORD	INVENTORY CONTROL LEDGER	DEPARTMENT BUDGET RECORD	ALLOTMENT RECORD

[illegible] ☆ U. S. GOVERNMENT PRINTING OFFICE : [illegible]

Figure 10-3.—Stub Requisition (SandA Form 307).

is filled out by your department to notify the supply officer to request a replacement. When the supply officer receives the stub informing him that your department has issued a repair part, he will prepare a replacement requisition.

Requisitioning Without Stock Numbers

On occasion, you may need to requisition a repair part for which no stock number is given. Identification must be made by giving the full nomenclature, drawing or other identifying number, name plate data (if any), and other existing information. In order that all available information may be recorded in a uniform manner, your division may be asked to fill out and send with a stub requisition a Request for Spare Parts (SandA Form 302). This form is shown in figure 10–4.

Transfers

At times, transfers of ordnance equipment and repair parts may be made to other naval ships. These transfers are made only by the supply officer on regular transfer invoices. After the transfer is made, the item will be written off your repair parts stock card (if one is maintained), and a replacement requisition prepared.

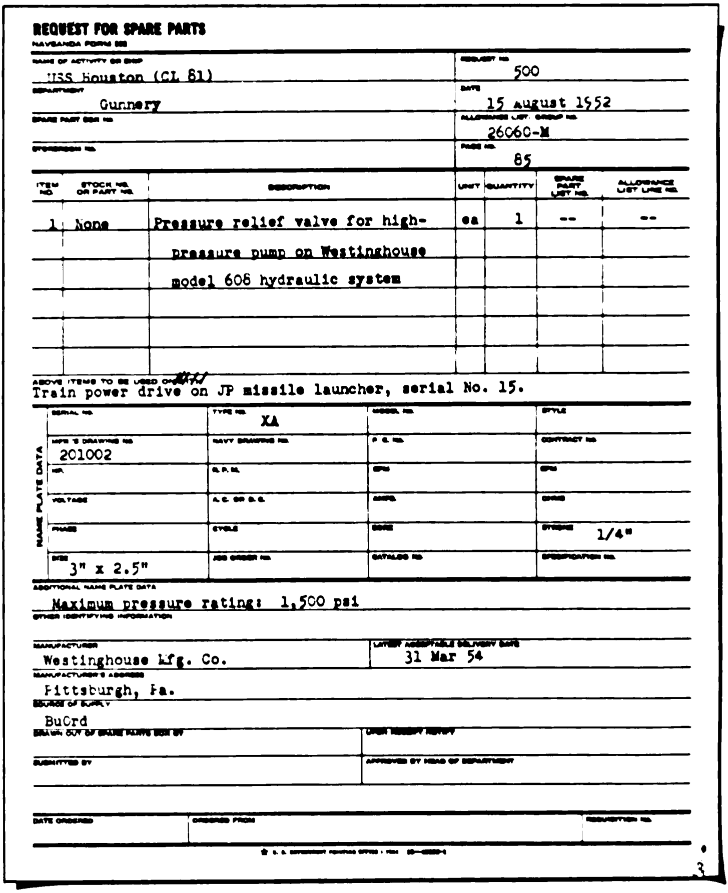
From time to time your ship will be directed to transfer ordnance equipment to a shore activity because it is obsolete or has been replaced. If no specific instructions regarding repair parts are received from the activity ordering you to make the transfer, then the full complement of repair parts for the equipment will also be turned over to the receiving activity.

SHIPBOARD ORDNANCE EQUIPMENT SUPPLY RECORDS

Stock Records

Your supply officer keeps a complete record of every kind of ordnance equipage aboard (with the exception of repair parts), whether it is on the allowance list or not.

To keep this record, he uses the Equipage Stock Card and



REQUEST FOR SPARE PARTS
NAVSANDA FORM 302

NAME OF ACTIVITY OR SHIP: USS Houston (CL 81)
REQUEST NO.: 500
DEPARTMENT: Gunnery
DATE: 15 August 1952
SPARE PART BOX NO.:
ALLOWANCE LIST, GROUP NO.: 26060-M
STOREROOM NO.:
PAGE NO.: 85

ITEM NO.	STOCK NO. OR PART NO.	DESCRIPTION	UNIT	QUANTITY	SPARE PART LIST NO.	ALLOWANCE LIST LINE NO.
1	None	Pressure relief valve for high-pressure pump on Westinghouse model 608 hydraulic system	ea	1	--	--

ABOVE ITEMS TO BE USED ON: Train power drive on JP missile launcher, serial No. 15.

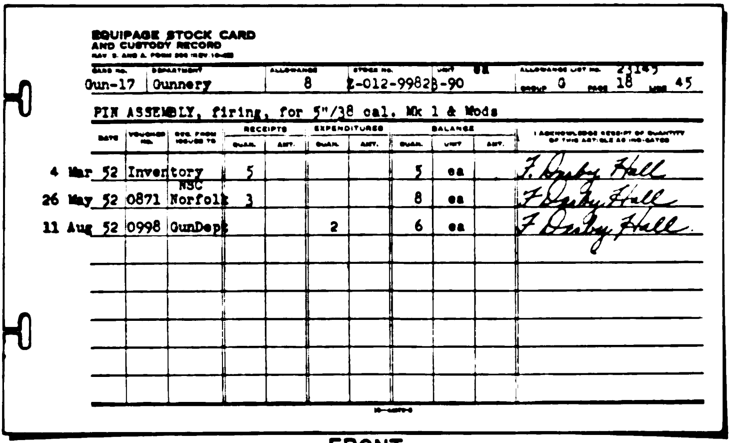
NAME PLATE DATA

SERIAL NO.	TYPE NO. XA	MODEL NO.	STYLE
MFR'S DRAWING NO. 201002	NAVY DRAWING NO.	P. C. NO.	CONTRACT NO.
HP.	R. P. M.	GPM	GPM
VOLTAGE	A. C. OR D. C.	AMPS.	GPM
PHASE	CYCLE	BORE	STROKE 1/4"
SIZE 3" x 2.5"	JOB ORDER NO.	CATALOG NO.	SPECIFICATION NO.

ADDITIONAL NAME PLATE DATA: Maximum pressure rating: 1,500 psi
OTHER IDENTIFYING INFORMATION:
MANUFACTURER: Westinghouse Mfg. Co.
LATEST ACCEPTABLE DELIVERY DATE: 31 Mar 54
MANUFACTURER'S ADDRESS: Pittsburgh, Pa.
SOURCE OF SUPPLY: BuOrd
DRAWN OUT OF SPARE PARTS BOX BY:
UPON RECEIPT NOTIFY:
SUBMITTED BY:
APPROVED BY HEAD OF DEPARTMENT:
DATE ORDERED:
ORDERED FROM:
REQUISITION NO.:

Figure 10–4.—Request for Spare Parts (SandA Form 302).

Custody Record (SandA Form 306). (Fig. 10–5.) The cards show all receipts and expenditures of equipage, and also the balance on hand. Except for certain ordnance equipage which requires no signed responsibility, each entry on the cards will be signed by your department head to show that he has received the quantity shown in the balance column. The items which require no custody signature are indicated by an asterisk in the ordnance equipage list mentioned earlier in this chapter.



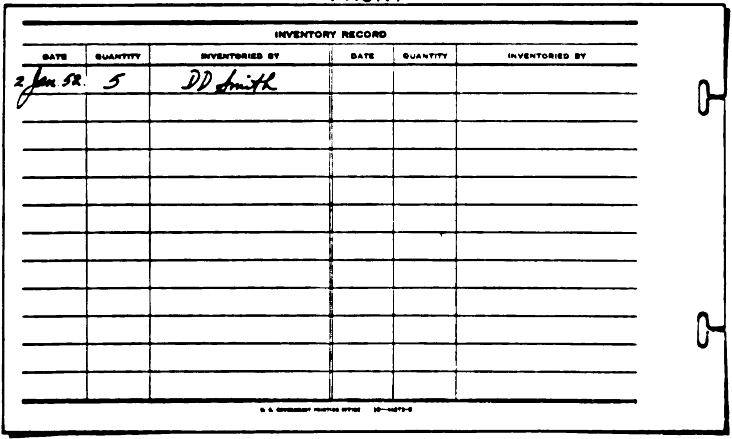
EQUIPAGE STOCK CARD
AND CUSTODY RECORD

CARD NO.	DEPARTMENT	ALLOWANCE	STOCK NO.	UNIT	ALLOWANCE LIST NO. 23145
Gun-17	Gunnery	8	Z-012-9982B-90	EA	GROUP G PAGE 18 LINE 45

PIN ASSEMBLY, firing, for 5"/38 cal. Mk 1 & Mods

DATE	VOUCHER NO.	REC. FROM ISSUED TO	RECEIPTS QUAN.	RECEIPTS AMT.	EXPENDITURES QUAN.	EXPENDITURES AMT.	BALANCE QUAN.	BALANCE UNIT	BALANCE AMT.	I ACKNOWLEDGE RECEIPT OF QUANTITY OF THIS ARTICLE AS INDICATED
4 Mar 52	Inventory		5				5	ea		F. Digby Hall
26 May 52	0871	NSC Norfolk	3				8	ea		F. Digby Hall
11 Aug 52	0998	GunDept			2		6	ea		F. Digby Hall

FRONT



INVENTORY RECORD

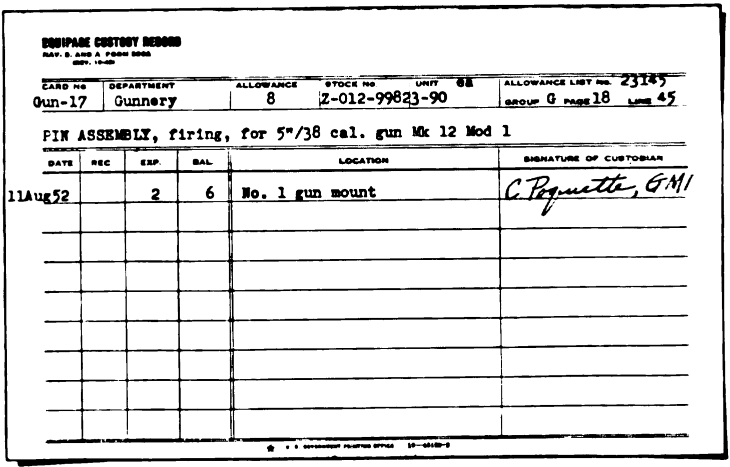
DATE	QUANTITY	INVENTORIED BY	DATE	QUANTITY	INVENTORIED BY
2 Jan 52	5	DD Smith			

BACK

Figure 10–5.—Equipage Stock Card and Custody Record (SandA Form 306).

Your department head keeps a duplicate set of Form 306 cards (copies of those the supply officer has) for the material assigned to your department. He is responsible for entering a record of all receipts and expenditures on his cards.

You will also be using the Equipage Custody Record (SandA Form 306A). This card (fig. 10–6) is used within your department to show the location of the material and



EQUIPAGE CUSTODY RECORD
NAV. S. AND A. FORM 306A
(REV. 10-[illegible])

CARD NO	DEPARTMENT	ALLOWANCE	STOCK NO	UNIT	ALLOWANCE LIST NO.
Gun-17	Gunnery	8	Z-012-99823-90	EA	23145 GROUP G PAGE 18 LINE 45

PIN ASSEMBLY, firing, for 5"/38 cal. gun Mk 12 Mod 1

DATE	REC	EXP.	BAL.	LOCATION	SIGNATURE OF CUSTODIAN
11Aug52		2	6	No. 1 gun mount	C. Paquette, GM1

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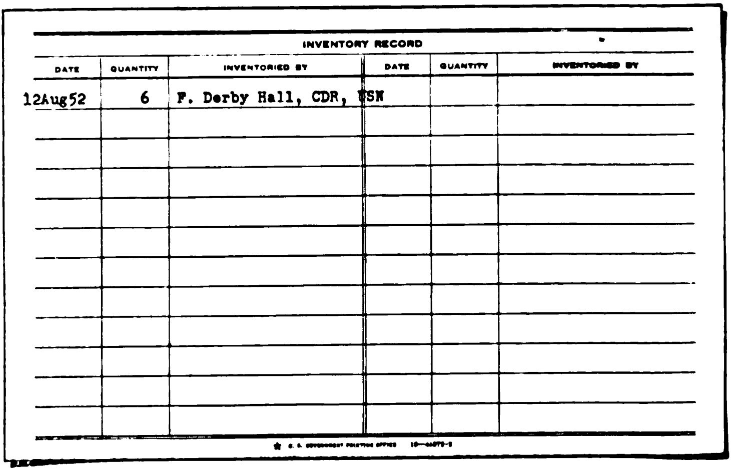
FRONT



INVENTORY RECORD

DATE	QUANTITY	INVENTORIED BY	DATE	QUANTITY	INVENTORIED BY
12Aug52	6	F. Derby Hall, CDR, USN			

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BACK

Figure 10–6.—Equipage Custody Record (SandA Form 306A).

who has custody of it. Form 306A may be used in the gunnery departments of some ships in place of Form 306.

The items your department head has signed for on Form 306 cards are shown on the 306A cards. When you are assigned an item by the gunnery officer, he will get your signature on the appropriate 306A custody record. He will furnish you with a carbon copy of each custody record you have signed. If you have to issue the material for which you've signed to someone else, get a receipt for it. Keep the receipt until you get the material back.

Inventory Records

An annual inventory is taken at some time during each fiscal year. (The fiscal year runs from 1 July to the following 30 June.) Your department head is responsible for the inventory of ordnance material over which he has custody, but the actual date is set by the supply officer.

Chances are that before the inventory takes place you will be asked to see that the material in storage over which your department has custody is arranged, so far as possible, in accordance with the following requirements:

1. Storage is in accordance with a definite stowage plan set up for the whole ship.
2. Sea stowage arrangements are modified to make inventory convenient.
3. Loose articles are repackaged in standard bulk lots where possible.
4. All stock is labeled and clearly identified.
5. Cartons and containers are stowed with all identifying information facing out.
6. Containers with broken seals are checked to see if a full count of material is there and the container marked to show the actual count.

As soon as the inventory is completed, your department enters on the back of each Equipage Custody Record (Form 306A) the date of the inventory, the quantity of material on hand, and the signature of the officer in charge of the inventory. The figure on the back of the equipage custody record should correspond with the actual number of items on hand by inventory. (Fig. 10–6.)

The information listed on the back of the Equipage Custody Record (Form 306A) also goes on the set of the Equipage Stock Card and Custody Record (Form 306) kept by your department head. Eventually, this information will also be entered on the back of the set of Equipage Stock Card and Custody Record forms kept by the supply officer.

SURVEY OF ORDNANCE MATERIAL

When material is damaged, worn out, missing, stolen, or otherwise not available for use, a SURVEY must be made to obtain proper authority to write this material off the books. Let's think of a survey as being an administrative examination into the cause of material being lost to use.

A survey may be either INFORMAL or FORMAL, depending on the circumstances in the case in question.

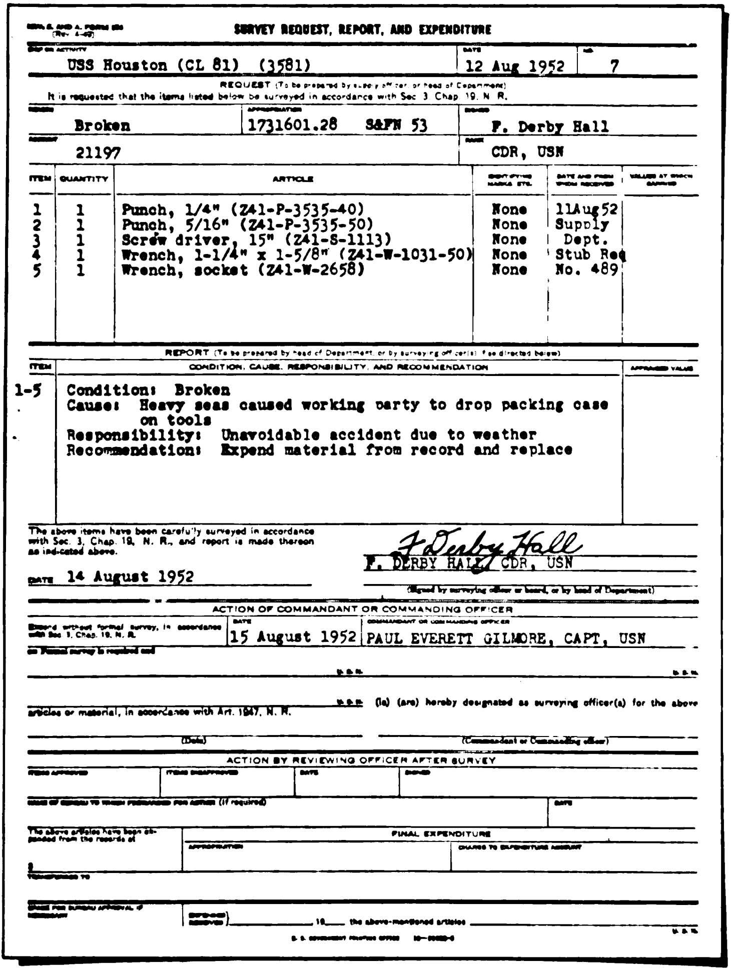
When a survey becomes necessary in your department, the gunnery officer makes up a rough REQUEST FOR SURVEY and gives it to the supply officer. (Or it may happen that you, as a Chief Gunner's Mate, will make up the rough for the gunnery officer to approve.) The request lists the nature of the material and the conditions making the survey necessary. The request is made on a Survey Request, Report, and Expenditure Form (SandA Form 154). (Fig. 10-7.)

The supply officer prepares a smooth typewritten Form 154 from this rough draft. This shows the requested information and a description of the article involved. The request from your department is then attached to the form. The supply officer sends ALL the papers to the commanding officer for appropriate action.

When the commanding officer receives this information, he decides which type of survey is required.

Formal Surveys

Formal surveys are required for Ordnance EQUIPAGE when it is lost, damaged, or worn beyond economical repair. (For what constitutes ordnance equipage, refer to chapter 2, volume 3, paragraph 32600 of the *BuSandA Manual.*) Your commanding officer can make the final decision on formal surveys of such material without consulting BuOrd, unless he feels that the facts in the case are such that the



NAV. S. AND A. FORM 154 (Rev. [illegible])

SURVEY REQUEST, REPORT, AND EXPENDITURE

SHIP OR ACTIVITY	DATE	NO.
USS Houston (CL 81) (3581)	12 Aug 1952	7

REQUEST (To be prepared by supply officer or head of Department)

It is requested that the items listed below be surveyed in accordance with Sec 3, Chap. 19, N. R.

REASON	APPROPRIATION	SIGNED
Broken	1731601.28 S&FN 53	F. Derby Hall

AMOUNT	RANK
21197	CDR, USN

ITEM	QUANTITY	ARTICLE	IDENTIFYING MARKS, ETC.	DATE AND FROM WHOM RECEIVED	VALUED AT WHICH CARRIED
1	1	Punch, 1/4" (Z41-P-3535-40)	None	11Aug52	
2	1	Punch, 5/16" (Z41-P-3535-50)	None	Supply	
3	1	Screw driver, 15" (Z41-S-1113)	None	Dept.	
4	1	Wrench, 1-1/4" x 1-5/8" (Z41-W-1031-50)	None	Stub Req	
5	1	Wrench, socket (Z41-W-2658)	None	No. 489	

REPORT (To be prepared by head of Department, or by surveying officer(s) if so directed below)

ITEM	CONDITION, CAUSE, RESPONSIBILITY, AND RECOMMENDATION	APPRAISED VALUE
1-5	Condition: Broken Cause: Heavy seas caused working party to drop packing case on tools Responsibility: Unavoidable accident due to weather Recommendation: Expend material from record and replace	

The above items have been carefully surveyed in accordance with Sec. 3, Chap. 19, N. R., and report is made thereon as indicated above.

DATE 14 August 1952

F Derby Hall

F. DERBY HALL, CDR, USN

(Signed by surveying officer or board, or by head of Department)

ACTION OF COMMANDANT OR COMMANDING OFFICER

Expend without formal survey, in accordance with Sec 3, Chap. 19, N. R.	DATE	COMMANDANT OR COMMANDING OFFICER
	15 August 1952	PAUL EVERETT GILMORE, CAPT, USN

or Formal survey is required and

_______________ U. S. N. _______________ U. S. N.

_______________ U. S. N. (is) (are) hereby designated as surveying officer(s) for the above articles or material, in accordance with Art. 1947, N. R.

(Date) (Commandant or Commanding officer)

ACTION BY REVIEWING OFFICER AFTER SURVEY

ITEMS APPROVED	ITEMS DISAPPROVED	DATE	SIGNED

NAME OF BUREAU TO WHICH FORWARDED FOR ACTION (if required) DATE

The above articles have been expended from the records of $

FINAL EXPENDITURE

APPROPRIATION CHARGE TO EXPENDITURE ACCOUNT

TRANSFERRED TO

SPACE FOR BUREAU APPROVAL IF NECESSARY

EXPENDED / REMOVED _______________ 19___ the above-mentioned articles _______________ U. S. N.

U. S. GOVERNMENT PRINTING OFFICE [illegible]

Figure 10-7.—Survey Request, Report, and Expenditure Form (SandA Form 154).

Bureau would have to give approval. However, he will probably send an information copy of formal surveys in order for the Bureau to request other action if necessary. If the CO decides on a formal survey, and the value of the material is less than $100, he may appoint any commissioned officer to make the survey so long as he is not a member of the gunnery department. If the value of the lost or missing equipage is over $100, or if for some other reason the commanding officer deems it advisable, a survey board of three officers is appointed rather than a single surveying officer.

A formal survey of other material may be held whenever the commanding officer feels that it is necessary.

Informal Surveys

As a rule, informal surveys are held for routine matters. If the circumstances are such that it appears that no disciplinary action by the commanding officer is in order, he will probably direct that an informal survey be held.

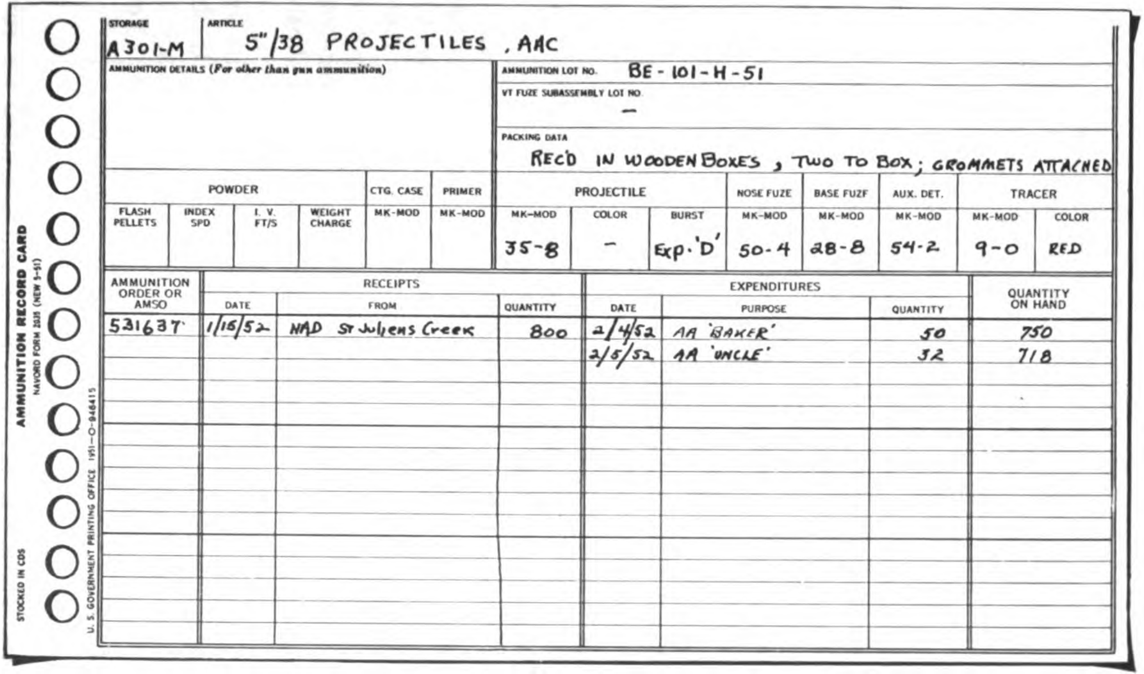
The distinguishing feature of the informal survey is that the head of the department requesting the action is usually appointed the surveying officer.

Whether formal or informal, the surveying officer is responsible for conducting a full and impartial investigation into the circumstances surrounding the survey and for preparing a written report on SandA Form 154.

When the survey is completed, the reports are prepared and signed by the surveying officer or officers. They are then given to the commanding officer for review and approval or rejection. If the commanding officer decides to reject any or all of the survey report, he can direct that a new set of papers be drawn up for the items he has disapproved. In this case, a new survey is made. (This second survey will ALWAYS be a formal one.) Then, if the report of the surveying officer is not changed to meet the CO's approval, the entire matter is referred to the responsible bureau for its consideration.

Provided all goes well and your department gets the approved survey back from the commanding officer, the officer in charge of the material will write it off in accordance with the terms of the survey.

The records taken up so far in this chapter have been those required by BuSandA. There are some additional forms



AMMUNITION RECORD CARD
NAVORD FORM 2035 (NEW 5-51)
STOCKED IN CDS
U. S. GOVERNMENT PRINTING OFFICE 1951—O-946415

STORAGE A301-M
ARTICLE 5"/38 PROJECTILES, AAC
AMMUNITION DETAILS (*For other than gun ammunition*)
AMMUNITION LOT NO. BE-101-H-51
VT FUZE SUBASSEMBLY LOT NO. —
PACKING DATA RECD IN WOODEN BOXES, TWO TO BOX; GROMMETS ATTACHED

POWDER				CTG. CASE	PRIMER	PROJECTILE			NOSE FUZE	BASE FUZF	AUX. DET.	TRACER	
FLASH PELLETS	INDEX SPD	I. V. FT/S	WEIGHT CHARGE	MK-MOD	MK-MOD	MK-MOD	COLOR	BURST	MK-MOD	MK-MOD	MK-MOD	MK-MOD	COLOR
						35-8	—	Exp. 'D'	50-4	28-8	54-2	9-0	RED

AMMUNITION ORDER OR AMSO	RECEIPTS			EXPENDITURES			QUANTITY ON HAND
	DATE	FROM	QUANTITY	DATE	PURPOSE	QUANTITY	
531637	1/15/52	NAD St Juliens Creek	800	2/4/52	AA 'BAKER'	50	750
				2/5/52	AA 'UNCLE'	32	718

Figure 10-8.—Ammunition Record Card (NavOrd Form 2035).

you should be familiar with. These are forms required by the Bureau of Ordnance or your gunnery officer.

The reports required periodically by BuOrd are constantly changing; the forms themselves are revised periodically, and the number and type of reports vary from one period to another. To keep yourself up to date, keep abreast of the latest instructions issued by the Bureau.

AMMUNITION RECORDS

A record should be kept of all ammunition on the ship. This ammunition record shows all receipts, expenditures, transfers, and the amount of ammunition on hand. You should completely identify all ammunition listed, giving the lot number as well as mark and mod of all the ammunition components.

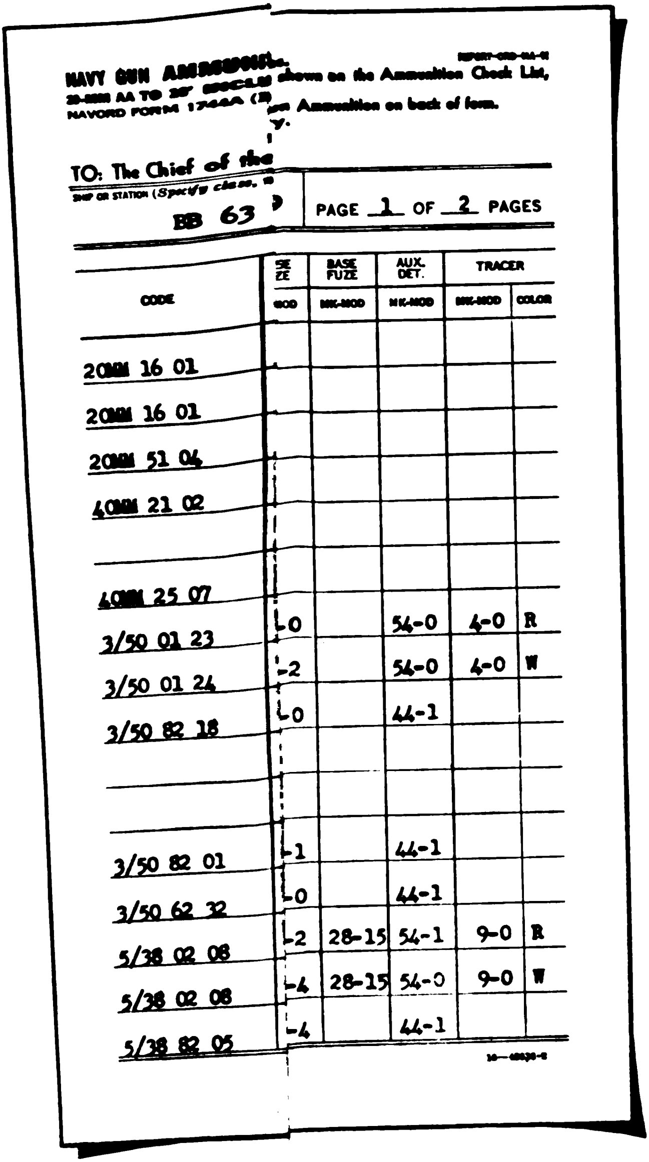
Identification data are found—

1. Stenciled on ammunition containers and on separate loading projectiles.
2. On tags secured to cartridge and powder tanks.
3. On ammunition data cards placed inside each container.
4. Stamped on ammunition components.

The standard form (NavOrd Form 2035) for ammunition records is shown in figure 10–8. Keep your ammunition record complete and up to date. BuOrd occasionally recalls from service ammunition assembled with certain components. These components are recalled by lot number as well as mark and mod. When such a directive is received by your department, you must check all ammunition aboard to see if any falls in the categories wanted by BuOrd. If you have kept your ammunition record up to date, the job will be a simple matter of referring to your files. If the record has not been properly kept, it may be necessary to check each round or case of ammunition on board. You can easily see what a headache this could become.

Ammunition Inventories

Reports of ammunition on hand and expended are submitted to the Bureau of Ordnance annually as of 30 June.



[illegible]

NAVY GUN AMMUNITION shown on the Ammunition Check List,
[illegible] AA TO [illegible]
NAVORD FORM 1744A ([illegible]) Ammunition on back of form.
y.

TO: The Chief of the

SHIP OR STATION (*Specify class,*)
BB 63

PAGE 1 OF 2 PAGES

CODE	FUZE	BASE FUZE	AUX. DET.	TRACER	
	MOD	MK-MOD	MK-MOD	MK-MOD	COLOR
20MM 16 01					
20MM 16 01					
20MM 51 04					
40MM 21 02					
40MM 25 07					
3/50 01 23	-0		54-0	4-0	R
3/50 01 24	-2		54-0	4-0	W
3/50 82 18	-0		44-1		
3/50 82 01	-1		44-1		
3/50 62 32	-0		44-1		
5/38 02 08	-2	28-15	54-1	9-0	R
5/38 02 08	-4	28-15	54-0	9-0	W
5/38 82 05	-4		44-1		

[illegible]

Figure rd Form 1744A)

tridges ALM PJR-46-HAN-45 assembled with FS Co.
ses to be turned in for replacement in accordance
JCL A16-49.

TIONS HAVE BEEN REPORTED TO THE BUREAU IN ACCORDANCE WITH EXISTING INSTRUCTIONS

APPROVED
AND FORWARDED

Ordnance officer)

(Commanding officer)

INSTRUCTIONS

a (20-mm AA to 16" inclusive) is
Use NAVORD FORM 1744B for
ition listed therein.

be listed in the sequence shown in
K LIST (NAVORD FORM 1744)
I therein to identify the item being

IA, reporting Gun Ammunition ex-
ar and on hand 30 June, is to be
nnually to the Bureau of Ordnance

cept vessels of the Reserve Fleet.
Gun Ammunition on board, or that
Ammunition allowance.

Reserve shore activities that ex-
Ammunition on hand. However,
at report through the Ammunition
em will not submit NAVORD

I account for their own ammunition
r elsewhere. If stored elsewhere,
rage should be noted. At time of
ation, prior to turn in of ammuni-
4A shall be submitted listing Gun
uantity expended since last report.
under "Remarks" indicating dis-
ms reported on hand.

made out from an actual physical
eviously submitted report.

unition on this form:

AMMUNITION CHECK LIST—

NAVORD FORM 1744). rounds on hand, ammunition lot number(s), VT fuze subassembly lot number(s), and complete details of assembly" for all Gun Ammunition (except 20-mm AA and 40-mm) in the appropriate columns for "Gun Ammunition on Hand."

(1) Where the details of assembly under the same "Code" differ in any respect, the dissimilar items are to be listed on separate lines and totaled separately. When more than one ammunition lot number is listed under the same "Code" and the details of assembly are identical for each lot, separate totals will not be reported for each lot. In the case of 20-mm AA and 40-mm ammunition, only the "code, rounds on hand, ammunition lot number(s) and powder indices" are required to be listed. Report separate totals of each powder index for all calibers of Gun Ammunition.

(2) If the round contains Flashless Pellets, place "X" in the column "F. P."

(3) When reporting FCL (VT) and FCL (VT) Non-Frag projectiles and cartridges assembled with VT fuzes, the fuze subassembly lot number(s) shall be listed directly below the ammunition lot number of the projectiles or cartridges into which it is assembled.

(4) List expenditures of all items of Gun Ammunition in the appropriate columns and show a total of the three columns. Expenditures for test purposes to be listed separately from "Training" expenditures and indicated as "Test." Active Fleet Ships to report separate totals for ammunition expended during Reserve and NROTC Student Cruises and to be noted on the report as "Reserves."

7. NAVORD FORM 1744A shall not be used to request disposition of ammunition. Any defective, obsolete, or unserviceable ammunition on hand should be listed under "Remarks" noting action taken to effect disposition.

BACK

GENERAL AMMUNITION REPORT
NAVORD FORM 1744B (Rev. 3/50)

Page 1 of 1 pages
REPORT-ORD-MA-12

2"25 500-8070-J	341	RMBF-975-NFCH-45	23	(RESERVES)		23
11"75 210-2030-J	99	RHFA-27-Y-45	4			4
11"75 701-1100-J	99	RMFA-55-S-45 RMFA-63-S-45	4			4
440-0110-M	99		4			4
		Demolition Material				
211-1050-E	80					

(Over)

FRONT

INSTRUCTIONS

1. The following classes of ammunition are to be reported on this form in the sequence shown in the AMMUNITION CHECK LIST (NAVORD FORM 1744) using the "Code" contained therein to identify the item being reported:

(a) Small Arms and 20-mm Aircraft (Army) Ammunition.
(b) Artillery and Landing Force Ammunition.
(c) Bombs and Bomb Fuzes.
(d) Pyrotechnics and Chemicals.
(e) Rocket-Type Ammunition.
(f) Demolition Material.

Note: Gun Ammunition (20-mm AA to 16" inclusive) is to be reported on NAVORD FORM 1744A.

2. NAVORD FORM 1744B, reporting ammunition expended during the fiscal year and on hand 30 June, is to be submitted (original only), annually to the Bureau of Ordnance by:

(a) U. S. Naval vessels, except vessels of the Reserve Fleet, that expended or have on board the classes of ammunition listed in paragraph 1(a) to 1(f), or that have authorized allowances of same.

(b) U. S. Naval and Marine aircraft squadrons that expended or have on hand the above classes of ammunition. Squadrons shall report ammunition expended and on hand from issues by ships and shore stations. Aircraft carriers shall not report ammunition expended by aircraft squadrons attached.

(c) U. S. Naval and Naval Reserve shore activities, except as modified below, that expended or have on hand the above classes of ammunition.

  (1) Shore activities having ammunition on hand for guard purposes only shall not submit reports.

  (2) Shore activities reporting through the Ammunition Stock Recording System shall not report except:

    (a) Naval air stations with units under control of Naval Air Training Command which shall submit reports of expenditures of the attached units.

    (b) Naval air stations with test centers which shall report expenditures for test purposes.

  (3) Naval air stations whose primary mission is air reserve training shall:

    (a) If under the Ammunition Stock Recording System report expenditures for air reserve training.

    (b) If not under the Ammunition Stock Recording System report both ammunition on hand and expended for air reserve training.

  (4) Naval Air Reserve Training Units shall submit separate reports.

3. Ships and stations shall account for their own ammunition whether stored on board or elsewhere. If stored elsewhere, the quantity and place of storage shall be noted. At time of decommissioning or inactivation, prior to turn in of ammunition, NAVORD FORM 1744B shall be submitted listing ammunition on hand and expended since last report. A notation shall be made under "Remarks" indicating disposition to be effected of items reported on hand.

4. This report should be made out from a physical inventory and not from a previously submitted report.

5. The above classes of ammunition shall be listed as major headings on the report and the ammunition items listed under heading by "Code." In reporting Small Arms Ammunition and Artillery and Landing Force Ammunition, the code under the column headed "Code" of the AMMUNITION CHECK LIST (NAVORD FORM 1744) is to be used in reporting and not the alternate codes.

6. Report the total number of rounds "On Hand" by "Code." It is not necessary to show the quantity for each "Ammunition Lot Number."

7. List expenditures in the appropriate columns and show a total of the three columns. Expenditures for test purposes to be listed separately from "Training" expenditures and indicated as "Test." Active Fleet Ships to report separate totals for ammunition expended during Reserve and NROTC Student Cruises and to be noted on the report as "Reserves."

8. NAVORD FORM 1744B shall not be used to request disposition of ammunition. Any defective, obsolete, or unserviceable ammunition on hand should be listed under "Remarks" noting action taken to effect disposition.

NAVORD FORM 1744B (BACK) (Rev. 2/50)

16—48637-2 U. S. GOVERNMENT PRINTING OFFICE

BACK

GENERAL REPORTING INSTRUCTIONS:

A. **FORCES AFLOAT.**—A complete report of installed armament shall be made annually on 1 July and upon commissioning or decommissioning, or on change of status from active to reserve, or vice versa. Any changes in installed armament or changes of any components thereof as listed above shall be reported at the time such changes occur. Changes are defined as transfers, issues, receipts, or disposals made in accordance with proper authority. Reports of spare components and subassemblies are required from tenders and repair ships only for items in tender stock.

B. **SHORE ACTIVITIES.**—All shore activities, including training establishments, having Ordnance material on hand for operation, stock and issue or storage shall report annually on 1 July all material on hand which is listed in this report. Installed equipment and components used for instructional purposes shall be included in the report. Changes (transfers, issues, receipts, disposals) shall be reported when such changes occur.

C. ***GENERAL.***—Activities having Ordnance material in store for stock and issue or storage must clearly indicate condition of subject equipment, using supplementary sheets, *if necessary*, to indicate deficiencies, *need for repair*, missing parts or components, etc. Unless otherwise indicated, material reported will be considered in issue condition. ***DO NOT*** *report separately* components or subassemblies which are part of larger components or assemblies.

FRONT

† Do not report fractional horsepower motors such as parallax motors, auxiliary pump motors, etc., which are reported in the OSO Reporting System.

NOTE: Where BuOrd Drawing Number is unknown, furnish full name plate data and application. Report these items only when not associated with larger components listed above.

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BACK

The reports are also submitted before ammunition is turned in when a ship is decommissioned or inactivated. These reports are submitted on NavOrd Form 1744A—Navy Gun Ammunition Report, 20 mm (except Aircraft) to 16″ inclusive; and NavOrd Form 1744B—General Ammunition Report. (Figs. 10–9 and 10–10.) The General Ammunition Report includes small arms and 20 mm aircraft (Army) ammunition, artillery and landing force ammunition, bombs and bomb fuzes, pyrotechnics and chemicals, and rocket type ammunition (including A/S projector charges). Instructions for completing the report are given on the reverse side of each form.

You will be furnished with an Ammunition Checklist (NavOrd Form 1744) to identify the ammunition by code number. The checklist is kept in the gunnery department for reference, but remember that it is revised from time to time. Make sure that you are using the latest issue.

ARMAMENT INVENTORY FOR BUORD

The Bureau requires that all ships submit a report of installed armament on board. This report is required of ships in commission on 1 July, or whenever changes occur. Changes mean transfers, receipts, issues, surveys, or disposal as directed by proper authority. The report is also submitted by ships upon commissioning or decommissioning and on change of status from active to reserve or vice versa.

These reports are submitted on the following forms:

NavOrd Form 1872—Gun and Mount Card (3″ to 5″).
NavOrd Form 1873—Gun and Mount Card (6″ to 16″).
NavOrd Form 1874—Gun and Mount Card (.30 cal. to 40 mm, Rocket Launchers and Projectors).

Only Form 1872 is illustrated (in fig. 10–11).

STORING MATERIAL

On thumbing through this chapter, you may find that you could classify the sections under HOW TO FIND IT, HOW TO GET IT, and HOW TO ACCOUNT FOR IT.

Now let's take up the final step in this chapter—HOW TO STORE IT.

As a GM 1 or Chief, you are responsible for supervising the stowage and preservation of ordnance material. It is your job to see that the material is properly stowed in the spaces alloted.

As you know, ordnance material, other than repair parts, is in the physical custody of the gunnery officer. You have also learned that there may be times when even the repair parts are in the custody of the gunnery department. If this is the case on your ship, you must know something about storing them.

Since you may be called on to supervise the stowage of many of the items used in your division, let's take up a few simple principles of proper stowage. Naturally, you aren't expected to know as much about stowage as a First Class or Chief Storekeeper, but the information outlined below will help you avoid a lot of hard work and headaches.

Repair parts boxes are stowed in special storerooms wherever possible. The things to consider are security and ease of handling. If you are responsible for the repair parts, you want them secure and where you can get at them when necessary.

If possible, storerooms are scattered about the ship in order to minimize the effects of any major casualty damage. but this, of course, is not for you to decide.

When it is not practical to stow repair parts boxes in storerooms, you should locate them where they will be secure and relatively easy to get at. They should always be kept under lock and key, if possible. You should assign a dependable man to be your storeroom keeper, one who will be responsible to you for seeing that stowage security is maintained. An authorized storeroom keeper should always be present when your storeroom is open and unauthorized persons should not have access.

Of course, your department officers are allowed to enter the storeroom to inspect equipment and supplies, and damage control personnel are allowed access to the space in performance of their duties. Other persons may be admitted as directed by the commanding officer.

Space Lay-Out

The physical lay-out of your storeroom will depend upon the construction of the part of the ship where it is located. You must make the best use of what space is available. In planning the use of your space, you should consider—

1. Maximum stowage capacity.
2. Access to all stores.
3. Orderly arrangement of all stores.
4. Security.

If you need enclosed bins, open racks, shelving, or other accessories, request them. Always be on the alert to make recommendations for improvements if you think they are needed.

Segregate your stores so that you can find what you want conveniently. A standard locator system (usually set up by your supply officer) can be used to identify the items you want.

Place items with the greatest turnover in the most accessible parts of the storeroom and try to locate these items as near as possible to the points where they are usually used. Locate heavy stores to minimize handling.

Storeroom Maintenance

Personnel assigned to the storerooms are responsible for the condition of the spaces provided. It will be your job to see that the spaces are kept clean and shipshape. You should provide a schedule for a daily sweepdown, and check the condition of paintwork, bins and shelves, blower and ventilation outlets. Keep useless and misplaced gear out of the storerooms.

Before storerooms are secured each night, the decks should be swept down, all cleaning gear and tools returned to their proper places, and all lights turned off. All loose gear, rags, paper, and miscellaneous scraps must be disposed of.

You should also maintain a careful check on the operating conditions of the spaces and equipment. Examine steam pipes, water pipes, valves, electrical fixtures, ventilation systems, watertight fittings, and fire fighting equipment daily, and report any deficiencies immediately to the proper authority.

Storerooms are not to be used for the stowage of personal gear, except on the approval of the commanding officer.

When you are notified that the ship is getting under way into open seas, have the storeroom personnel secure all stores and equipment for sea. Have shelf stock boarded up where necessary, and take whatever precautions are necessary to prevent shifting of stores. After securing is complete, report to the gunnery or supply officer, in accordance with ship's general orders.

For additional information on storage, consult volume 3, chapter 8, of the *BuSandA Manual*.

SUMMARY

This chapter has given you an outline of the Navy supply system as it affects ordnance material and you. To give you a broader understanding of how your job fits into the larger picture, we have discussed how the Navy supply system works. We have outlined responsibility for supply and functions of the Bureau of Ordnance.

You have seen how items are identified in the *Catalog of Navy Material* and how to use the Bureau of Ordnance Section to order material.

We have discussed the importance of allowance lists and methods of getting material—letters of request, and requisitions—and how to account for the material after you get it. We also mentioned a few of the NavOrd forms you will be using. You have learned about some of the other paper work that is required in your new rating as GM 1 or Chief and how to store the material after it is issued to your department.

It is impossible to cover everything in this text that you need to know about supply. The information you need will depend on the particular job you're assigned to and the nature of your particular ship or station. Therefore, when you need more detailed information to solve a problem in supply, consult the *BuSandA Manual,* or discuss your problem with the supply officer or one of his Storekeepers.

QUIZ

In each of the following, select the one BEST answer.

1. Which of the following is NOT found in the ordnance part of the *Catalog of Navy Material?*
   - a. a listing of all major calibers of gun ammunition
   - b. the major components and parts comprising a specific piece of equipment
   - c. the subassemblies and parts comprising a major component
   - d. the parts making up a subassembly
2. The cognizance symbol portion of a standard Navy stock number for ordnance is
   - a. a 3-digit number indicating the class of material
   - b. the portion identifying a specific item
   - c. the portion identifying the manufacturer
   - d. a code indicating the activity that has inventory control
3. In this chapter the term MATERIAL is NOT applied to which of the following items
   - a. Supplies
   - b. Ammunition
   - c. Equipment
   - d. Repair parts
4. The supply officer is responsible for requisitioning
   - a. ammunition
   - b. repair parts, small arms, and landing force equipment
   - c. fixed installations of ordnance equipment
   - d. all of the above
5. On most ships, a letter of request is normally prepared by
   - a. a GMC and signed by the supply officer
   - b. a Yeoman and signed by the executive officer
   - c. a GMC and signed by his gunnery officer
   - d. the gunnery officer and signed by the commanding officer
6. A letter of request must be used to obtain
   - a. pyrotechnics
   - b. general stores items
   - c. all portable ordnance material
   - d. all in-excess items

7. A not-in-excess requisition requires the signature of the
   a. supply officer only
   b. supply officer and the commanding officer
   c. department head and the supply officer
   d. department head and the commanding officer
8. Technical ordnance material designed for a specific purpose is usually paid for by the
   a. Navy Stock Fund
   b. Ordnance Stock Account
   c. Ordnance Supply Office
   d. Bureau of Ordnance
9. Ordnance repair parts must be requisitioned from the supply officer on
   a. NavSandA Form 307
   b. NavOrd Form 1874
   c. NavSandA Form 306
   d. NavSandA Form 154
10. Which of the following is a distinguishing feature of an informal survey?
    a. Three officers are appointed to the survey board
    b. The commanding officer conducts the survey
    c. The officer requesting the action is usually appointed the surveying officer
    d. The value of the material to be surveyed is over $100

CHAPTER 11

DEMOLITION MATERIALS AND TECHNIQUES

INTRODUCTION

Traditionally, the Gunner's Mate has been expected to be an expert not only on weapons but on explosives. In the early days, he mixed the gunpowder and made up the propelling charges for naval cannon. Nowadays, Gunner's Mates are expected to know how to blow up hazards to navigation (such as floating hulks) when necessary, how to destroy secret and confidential equipment by the use of explosives when capture by the enemy is imminent, and how to do similar odd jobs involving the handling and application of explosives other than those in ammunition. And Gunner's Mates in the Seabees must be familiar in great detail with the use of explosives in demolitions ashore, because that is one of the important aspects of their jobs.

In this chapter you will get a quick look at some of the demolition materials (including explosives) you're most likely to use, and you will study some of the more important methods of using them. But don't get the idea that reading this chapter will make you a demolition expert. If you're going to do a lot of blasting, you will probably get intensive training in one of the special Navy schools, like the Ordnance Disposal School at Indian Head, Maryland. In studying this chapter, remember always that it is just an INTRODUCTION to the subject of demolitions.

In the next section we'll give you a short description of the principal demolition materials and equipment you'll use. Later in the chapter we'll tell you how to use this equipment to place an explosive charge and set it off.

DEMOLITION EQUIPMENT

We shall first take up materials used for starting or INITIATING the blast. Let's begin with TIME BLASTING FUSE.

Time Blasting Fuse

Other names for time blasting fuse are BLASTING FUSE, TIME FUSE, SAFETY FUSE, and MINER'S SAFETY FUSE.

NOTE. This is FUSE spelled with an "S." The "Z" is used for FUZES on EXPLOSIVE PROJECTILES.

Blasting fuse is a cord with a core of black powder. (Fig. 11–1.) When you light the powder at one end of the cord, the flame travels slowly along the length of the fuse. When the flame reaches the end of the fuse it gives a final spurt that can set off a nonelectric blasting cap.

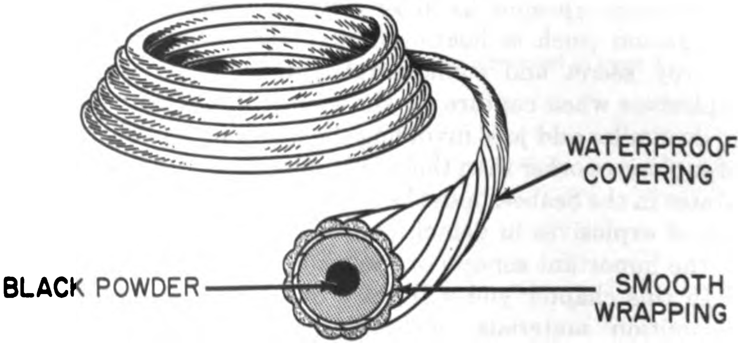


Figure 11–1.—Coil of time blasting fuse showing exposed end.

Time fuse is a quarter of an inch in diameter, often orange-colored outside, and wrapped with fabric; its black powder core is protected by waterproofing. It comes in 500-foot coils, each in a sealed metal can, or in 50-foot coils packed two to a container. A foot of this fuse takes 30 to 45 seconds to burn.

Note. In short lengths, it may burn a lot faster than that.

Don't depend on the looks of a fuse to identify it. Several foreign-made fuses and detonating cords look much like American blasting fuse. But the burning time of foreign time fuse may be much shorter, and any detonating cord is a high explosive. So don't use time fuse unless you know FOR SURE what its burning time will be, or unless you have time to test it thoroughly before you use it.

Special Blasting Caps

The SPECIAL NONELECTRIC BLASTING CAP (fig. 11–2) goes off when a spurt of flame like that produced by time fuse (which fits into its open end) enters its shell. Its FLASH CHARGE ignites a PRIMING CHARGE, which in turn detonates a BASE CHARGE of 13½ grains of PETN. Used properly, this cap can detonate any demolition charge designed for use with blasting caps. The process of inserting time fuse into its open end and crimping it in place is described later in this chapter.

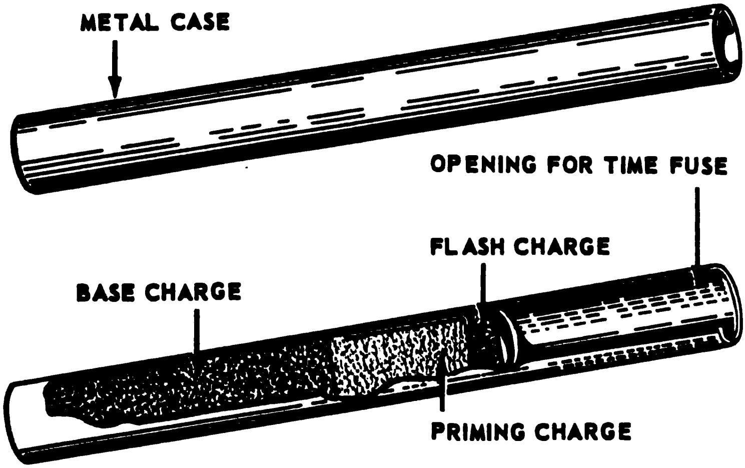


Figure 11–2.—Special nonelectric blasting cap.

The SPECIAL ELECTRIC BLASTING CAP (fig. 11–3), like the nonelectric cap, is strong enough to detonate any demolition charge designed for use with blasting caps. To explode this

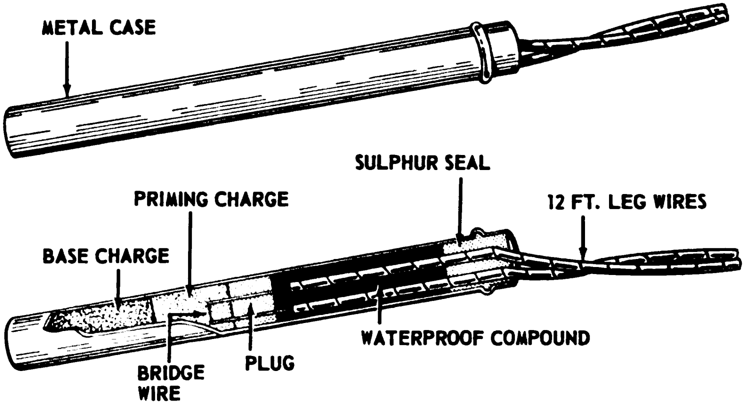


Figure 11–3.—Special electric blasting cap.

cap you use electricity rather than flame. When an electric current passes through the leg wires, it heats a bridge wire to ignite the priming charge. This detonates the base charge of 13½ grains of PETN.

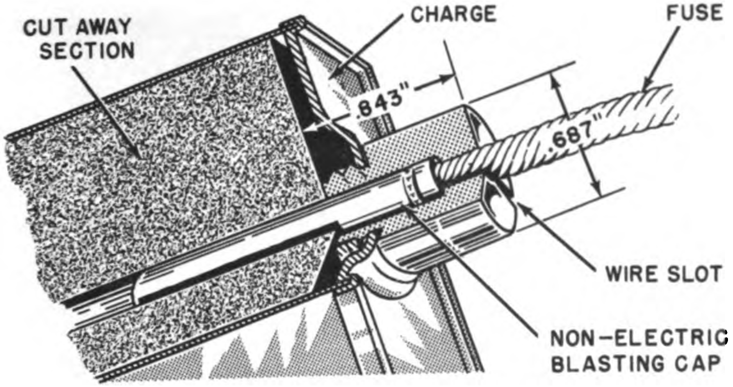
Priming Adapter

The priming adapter does not contain any explosive component. All it does is to hold a blasting cap—electric or nonelectric—in a cavity (the ACTIVATOR WELL) in an explosive charge. The adapter is a hollow plastic cylinder, with one end threaded to fit the threads of the activator well. Its inside diameter is just big enough to hold the cap. At the unthreaded end it's slightly smaller, to let the wires or blasting fuse pass through, while keeping the cap from slipping out. The adapter has a lengthwise slot through which you can slip the wires of an electric blasting cap for easy assembly.

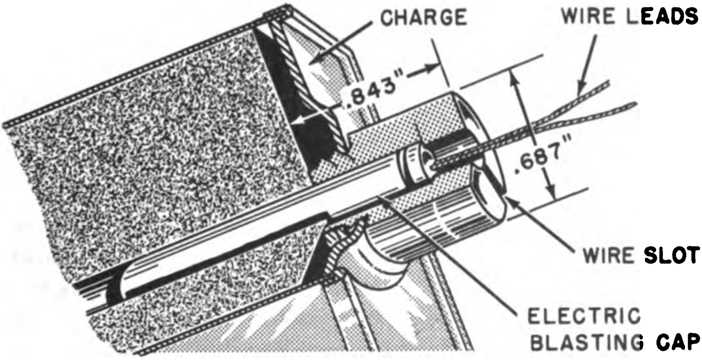
Figure 11–4 shows a cut-away view of a priming adapter fitted with a nonelectric cap and another of an adapter holding an electric cap.

Detonating Cord and Accessories

DETONATING CORD (also called PRIMACORD) looks a lot like time blasting fuse. But don't get the two mixed up. Time fuse, you remember, contains a low explosive that burns



A



B

Figure 11-4.—Priming adapters. A. With nonelectric cap. B. With electric cap.

slowly; after you light it, you have time to move away to a safe place. But primacord is packed with grains of PETN—a high explosive. When you initiate the primacord it does not burn slowly; it explodes throughout its whole length. It gives you NO time to get to a safe place. You must provide a time delay at the point where you detonate the cord. You'll do best to think of detonating cord as a high explosive—which it is—and not as time fuse—which it most certainly is not.

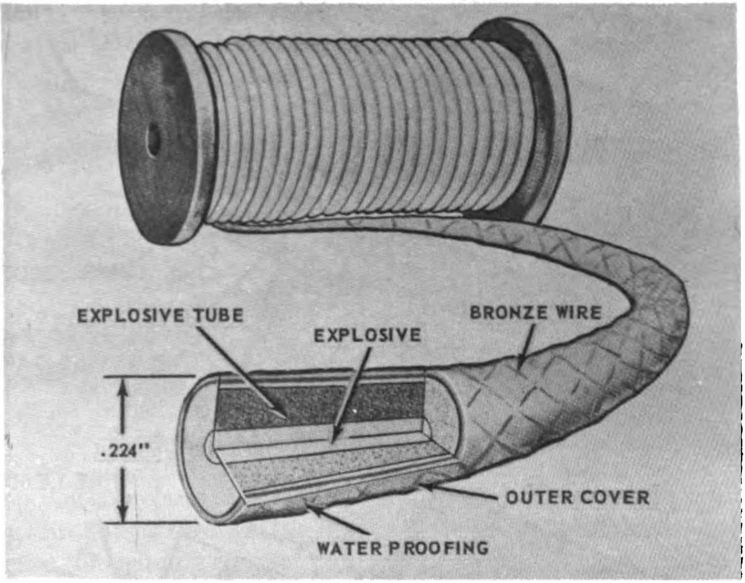


Figure 11–5.—Reinforced detonating cord.

Figure 11–5 shows a reinforced detonating cord of the kind most often used by the Navy. It's fairly insensitive, has a tensile strength of about 160 pounds, and is moderately resistant to abrasion. It has a waterproof rough waxy surface, often yellow or yellow-and-black, and it comes in 100-foot lengths on wooden spools.

To start the detonation of primacord you need a DETONATING CORD INITIATOR. (Fig. 11–6.) It contains a 15-grain pellet of tetryl for exploding the cord, and a capsule of lead azide for detonating the tetryl. The lead azide is fired by a blasting cap (electric or nonelectric) or percussion cap. Just before you're ready to fire, snap the primacord into the slot at the end of the initiator.

Ten-Cap Blasting Machine

To fire electric blasting caps, you need an electric current. The TEN-CAP BLASTING MACHINE (figure 11–7) is designed to provide a surge of current which, under ideal conditions, can fire as many as 10 caps connected in series. The machine

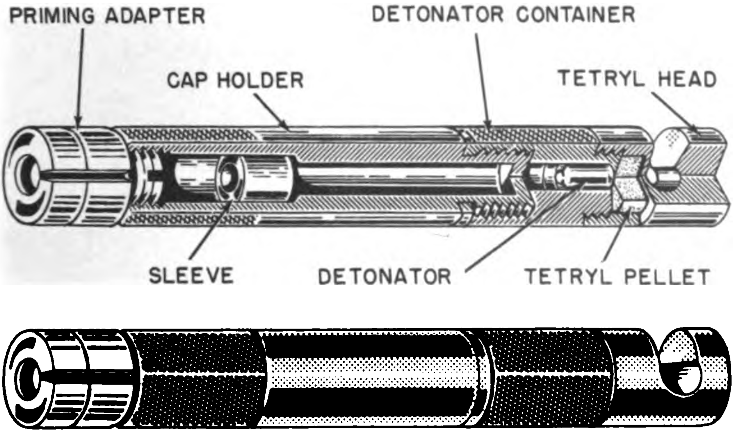


Figure 11–6.—Detonating cord initiator Mk 2 Mod 0.

contains a small electric generator in a weatherproof case. To operate it, give the handle a quick, clockwise twist. You can remove the handle and carry it with you while you're wiring up the charge, to be sure that no one operates the machine by mistake.

Another type is the THIRTY-CAP BLASTING MACHINE (not illustrated) built into a rectangular wooden case. It can fire 30 caps in series and is operated by raising the handle to the top of its stroke, then pushing it down rapidly.

Be sure never to leave the handle in the raised position while hooking up a charge. If the handle is moved down accidentally the charge will fire.

Weatherproof Fuse Lighter M2

It is possible to light off time fuse with matches. The technique is described later in this chapter. But a WEATHERPROOF FUSE LIGHTER M2 (fig. 11–8) can reliably do this job under any weather conditions. You can even use it to light a safety fuse under water. Before you submerge it, insert the fuse in the end of the lighter and seal it with a plastic sealing material. When you pull the release pin, the spring-~~loaded st~~riker ignites the primer, which lights the fuse.

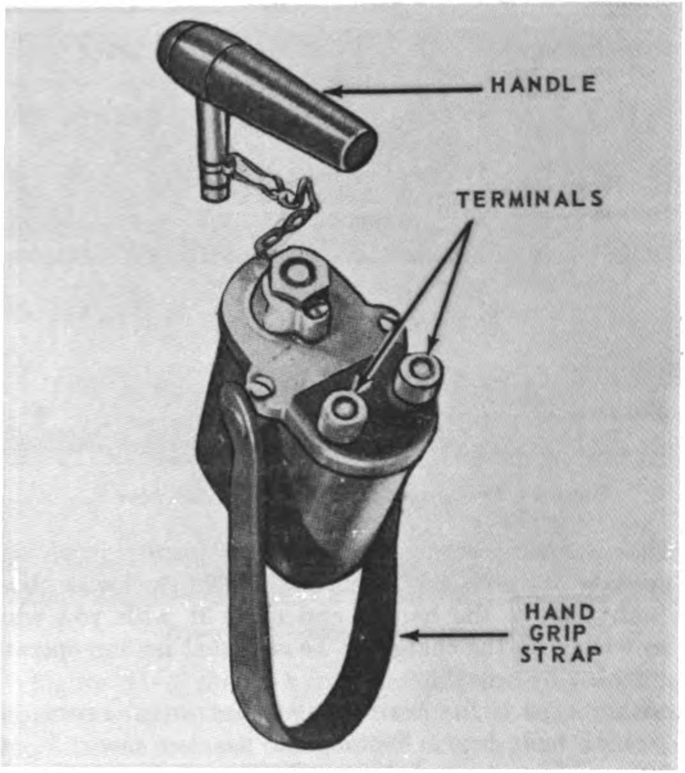


Figure 11-7.—Ten-cap blasting machine.

Demolition Firing Device Mk 12 Mod 0

The DEMOLITION FIRING DEVICE MK 12 MOD 0 (fig. 11-9) is useful as a substitute for time fuse. It's a clockwork mechanism designed to explode a demolition charge after a short time delay. The delay is adjustable, from 5 to 92 seconds. This device is rugged enough in normal service but like any clockwork mechanism, it deserves careful handling.

To operate the device, you pull out the cotter pin to unlock the arming pin. At the end of the set time, the firing pin strikes the mercury fulminate priming charge in the percussion cap, and it goes off to produce a spit of flame.

You can control the length of the delay by turning the calibrated head. The percussion cap will detonate either a

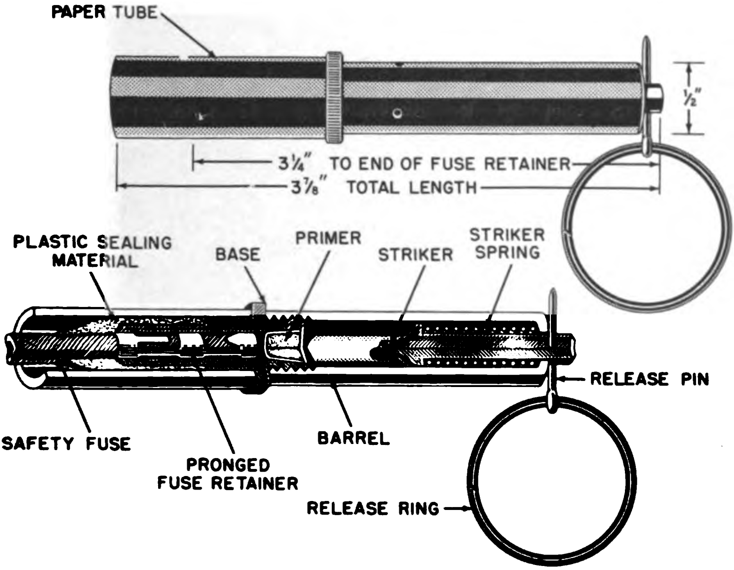


Figure 11–8.—Weatherproof fuse lighter M2.

nonelectric blasting cap or a detonating cord initiator Mk 2 Mod 0.

The demolition firing device Mk 15 Mod 0 (not illustrated) is much like the Mk 12, except that its time delay range is from 15 minutes to 11 hours.

Associated with both the Mk 12 and Mk 15 demolition firing devices (and usable with other mechanical firing devices also) is the coupling base (fig. 11–9, *C*), an adapter that holds the percussion cap so that the spit of flame issues from the snout of the coupling base. A nonelectric cap can be crimped to the snout. The threaded portion of the coupling base next to the snout mates with the thread of the standard activator well of the charges described elsewhere in this chapter; the finer thread at the other end permits the base to screw into the mechanical firing device.

Fifteen-Second Delay Detonator M1

The 15-second delay detonator M1 (fig. 11–10, *D*) is especially useful for assault demolitions ashore. It's water-

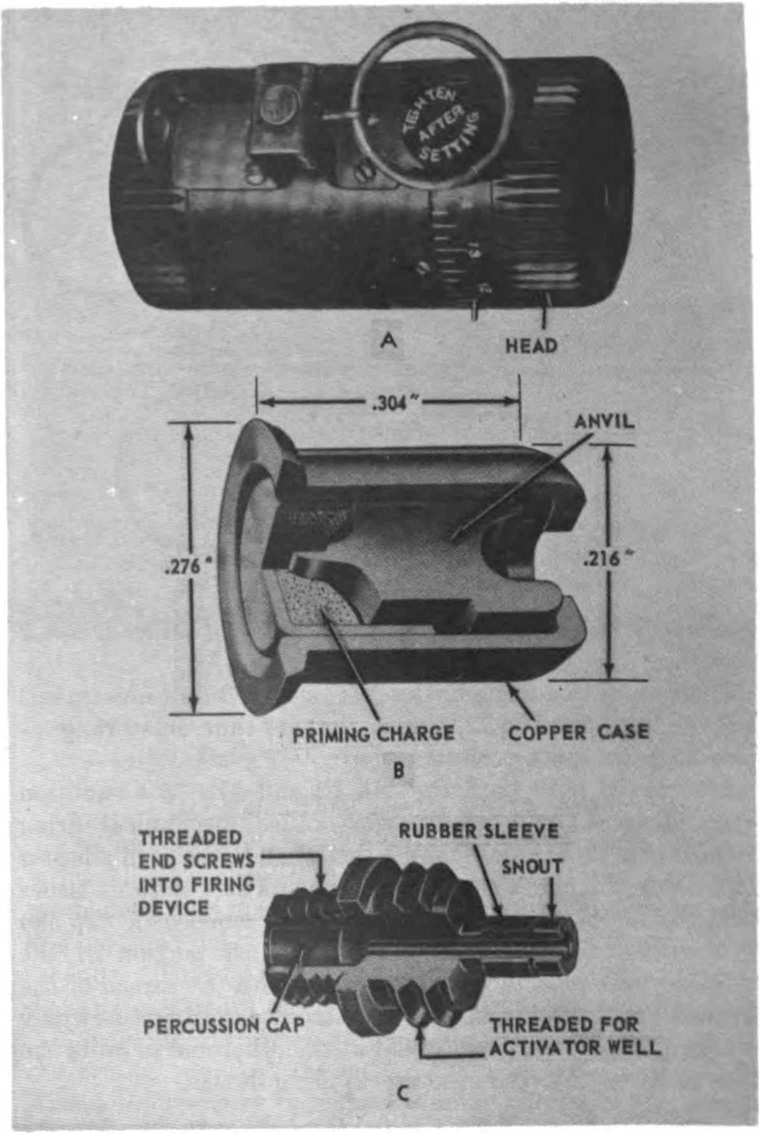


Figure 11–9.—Demolition firing device Mk 12 Mod 0. A. Exterior. B. Percussion cap. C. Coupling base.

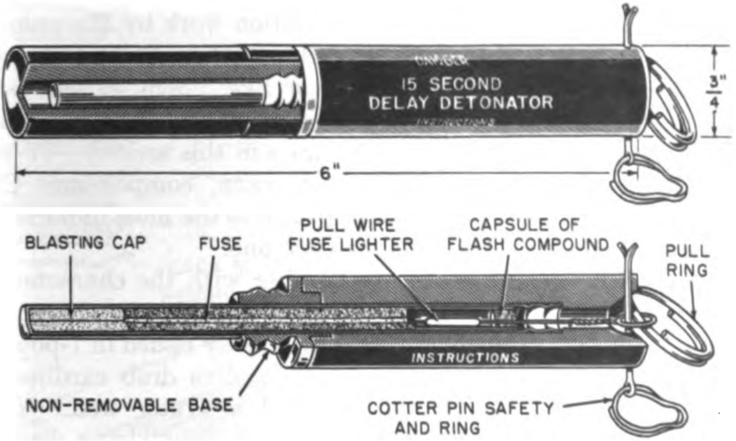


Figure 11–10.—Fifteen-second delay detonator M1.

proof, has a permanently attached blasting cap, and its base is threaded to fit a standard activator well.

By pulling the ring, you ignite a flash compound, which starts a powder train. After burning for about 15 seconds, the powder train fires the blasting cap.

The M2 detonator is exactly like the M1, except that its time delay is only about 8 seconds.

DEMOLITION CHARGES AND OUTFITS

Up to this point we have been concerned with devices used for initiating the blast. In the next few pages, we shall take up demolition explosives, the types of charges issued for use by Naval forces, and certain demolition outfits issued as complete sets. The Bureau of Ordnance issues a great variety of material of this kind; much of it is Army Engineer or Army Ordnance stock. The demolition materials discussed in this section are only the types common in Naval use. For fuller details on these items and on others not discussed here, see OP 1411, OP 1178, TM 9–1940, FM 5–25, and the *Blaster's Handbook* (issued by the DuPont Corporation, Wilmington, Del.).

Demolition Explosive Charges

All the explosives used for demolition work by the armed forces are high explosives. (It's assumed here that you know the technical meanings of terms like "high explosive," "detonation," "sensitivity," "brisance," and the like. If not, better review the earlier courses in this series.) These explosives include TNT, tetrytol, PETN, compositions C2 and C3, dynamite, and blasting gelatin as the most important ones. Let's take these up one by one.

1. TNT. You are already familiar with the characteristics of TNT, since it is widely used as a burster charge in many types of projectiles. It is commonly issued in 1-pound blocks (as in fig. 11–11), each in an olive drab cardboard container. One end has a threaded activator well. You can use this charge by itself or as a booster for a bigger charge. TNT also comes in half-pound blocks, in a yellow container with an unthreaded activator well.

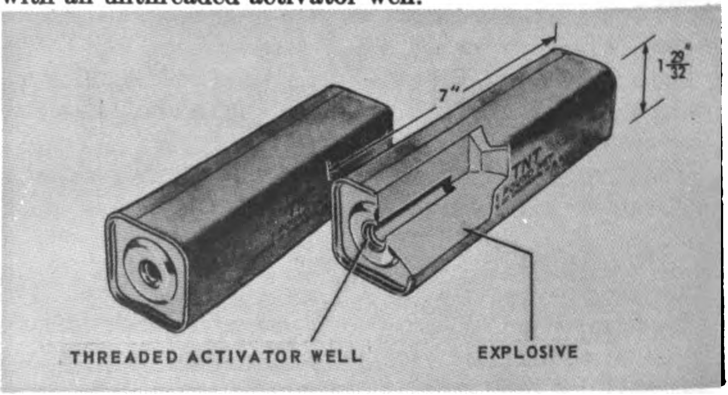


Figure 11–11.—One-pound TNT block.

You can use either of these charges under water. They're fairly insensitive to shock and small-arms fire.

2. Demolition chain blocks M1 and M2. The M1 chain consists of eight blocks of tetrytol cast 8 inches apart on a single line of detonating cord. (Fig. 11–12.) Each block contains 2½ pounds of tetrytol, with a tetryl booster at each end. The outfit comes in a cloth haversack. (Tetrytol is a mixture consisting of 75 percent tetryl and 25 percent TNT.)

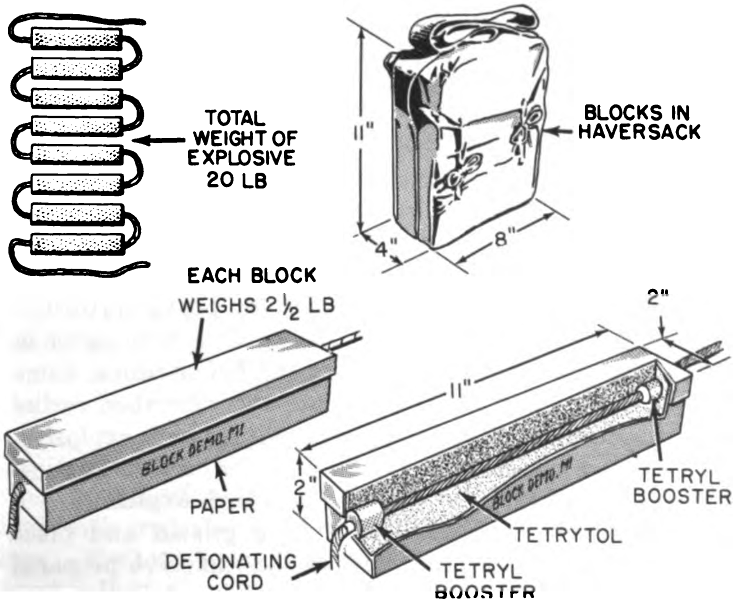


Figure 11–12.—Demolition chain blocks M1.

The M1 chain blocks are useful for general demolition work. They are somewhat more sensitive than TNT, but for cutting or breaching, they're more effective. You can cut the blocks apart and use them individually, if you want to. And you can use them under water.

Demolition blocks M2 are individual blocks, each containing 2½ pounds of tetrytol. They're much like the M1 chain blocks, and serve the same purpose. But the M2 block isn't cast on a detonating cord. Instead, it has at each end a threaded activator well surrounded by a booster. Eight blocks are packed in a cloth haversack.

3. Demolition block M3. These are 2¼-pound blocks of dark brown putty-like material (composition C2 or C3).

Compositions C2 and C3 are related to compositions A and B, which you are already acquainted with as high-explosive projectile fillers. The common ingredient in all of these is RDX. Compositions C2 and C3 are mixtures of RDX and oil.

M3 blocks are 25 percent more powerful than an equal weight of TNT. The explosive is plastic at all normal temperatures.

4. AMATOL is a mixture of TNT and ammonium nitrate. You have seen it mentioned before as an aircraft bomb explosive filler. It is not issued in the form of demolition blocks; it is used as the main explosive in the bangalore torpedo, which will be discussed later in this chapter.

5. PETN. This set of letters stands for penta-erythritol-tetra-nitrate, a granular powder that is the active agent in detonating cord. You needn't learn the full chemical name unless you want to. Detonating cord was described earlier in this chapter as an initiating agent, but it is a high explosive, can be used as a high explosive by itself for certain applications, and must always be treated like a high explosive.

6. DYNAMITE. This, like the blasting gelatin and black powder described below, is a COMMERCIAL explosive prepared and packed specifically for commercial use in mining, quarrying, and so on. There are three kinds: STRAIGHT, AMMONIA, and GELATIN.

a. STRAIGHT DYNAMITE consists fundamentally of nitroglycerin (a powerful, extremely sensitive liquid explosive) absorbed in a porous material.

b. AMMONIA DYNAMITES have a base of nitroglycerin plus ammonium nitrate, and are roughly equal in strength to straight dynamites. They are unsatisfactory for underwater use.

c. GELATIN DYNAMITE is a somewhat plastic explosive based on nitroglycerin and nitrocotton. Gelatin dynamite is suitable for underwater use.

7. BLASTING GELATIN, another commercial explosive, is a rubbery plastic substance closely related to gelatin dynamite, packaged in ½-pound paraffin-treated cartridges 1¼ inches in diameter and 8 inches long. Blasting gelatin is satisfactory for underwater use.

8. BLACK POWDER (fig. 11–13) as a commercial explosive is

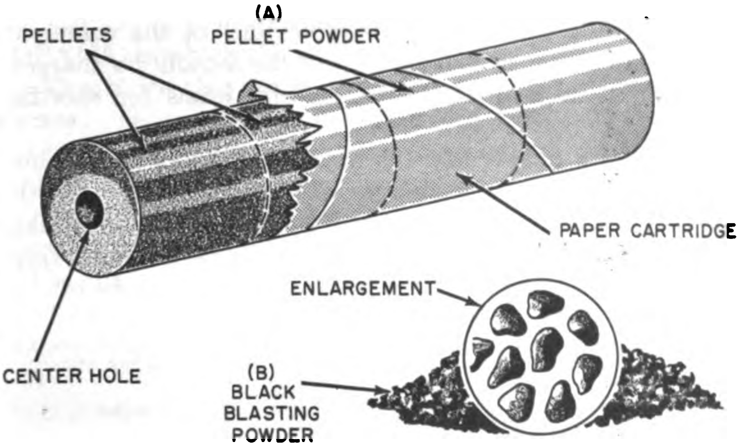


Figure 11-13.—Commercial black powder.

often packaged as BLACK BLASTING POWDER, a granulated form with irregularly shaped grains that comes in 25-pound kegs. PELLET POWDER is black powder pressed into cylindrical pellets about 2 inches long and 1⅛ inches to 2⅛ inches in diameter, which are wrapped in paraffin-dipped cartridges 8 inches long. Black powder is not a high explosive, but it is used for demolition and blasting.

Black powder must be tightly confined or tamped to obtain good results. It is ignited by flame-producing rather than detonating substances. Commercial black powder, like the military variety (from which it differs substantially only in packaging), is sensitive to flame and friction, is highly inflammable, and should be handled accordingly. Naturally, it must be kept dry in order to give satisfactory results; by the same token, it is not adapted to any but dry work.

All these commercial explosives are efficient for demolition work, but share the drawback of being sensitive to the impact of bullets and shell fragments. That is why you will most likely use TNT and tetrytol in demolition work.

Demolition Outfits and Special Demolition Charges

To simplify the placing and firing of groups of charges, they are often issued in DEMOLITION OUTFITS or sets rather than in bulk. This section describes one of the common demolition outfits, as well as some of the demolition charges made up in large quantities or special forms for specific applications.

Demolition outfit Mk 135 Mod 0. (Fig. 11-14.) This outfit contains 10 plastic charges, each primed with a length of detonating cord. The haversack has sash cords and hooks for attaching the charges to an obstacle, plus a towing ring and a compartment for a flotation bladder, so it can be towed through the water by a swimmer.

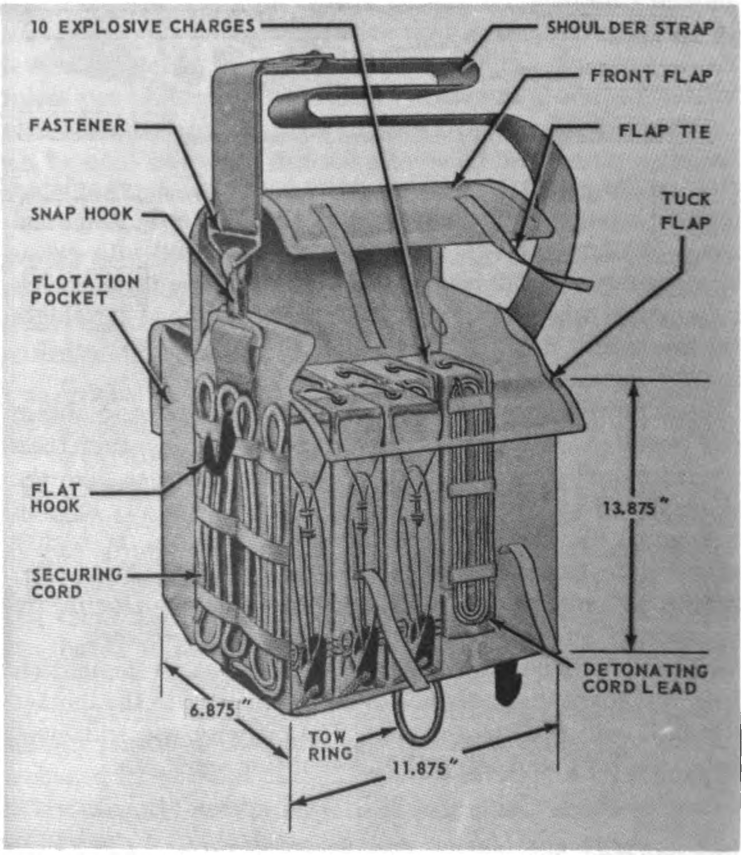


Figure 11-14.—Demolition outfit Mk 135 Mod 0.

The Mk 135 outfit is only one of a number described in OP 1178, to which the student is referred for further details.

The Navy also issues charges made up for special purposes. Three of these are described here. (But see OP 1178 for more comprehensive descriptions of these and others available.)

DEMOLITION CHARGE MK 2 MODS 0 AND 1. This is a rust-proofed metal can filled with about 55 pounds of cast TNT. This charge is specially adapted for underwater use. A half-pound TNT block fits in a cavity in the charge and serves as a booster. The firing cable passes through a stuffing box which keeps the water out. To fire the Mod 0 charge, you use an electric cap in the booster. Figure 11–15 shows Mod 0. Mod 1 has a few extra attachments and is modified to use a mechanical firing device.

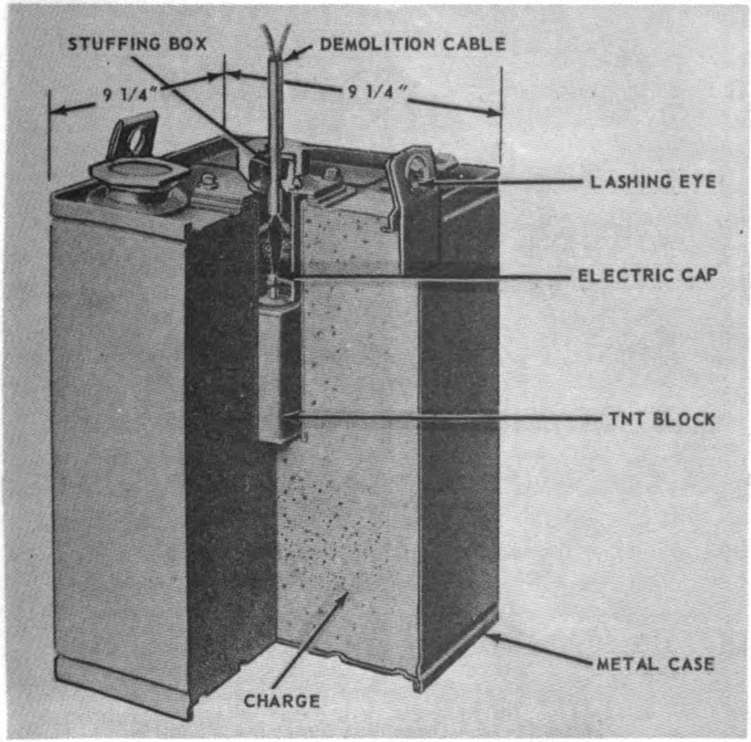


Figure 11–15.—Demolition charge Mk 2 Mod 0.

Demolition charge Mk 8 Mod 0. (Fig. 11–16.) This is a flexible, 2-inch rubber hose, 25 feet long. It is useful when you have to clear a path, or when you want to wrap the charge around an obstacle. The main charge is 50 pounds of flexed TNT. In one end is a booster Mk 8 (with cavity for blasting cap); in the other is a booster Mk 12 (with no cavity). The hose has a coupling at each end, so

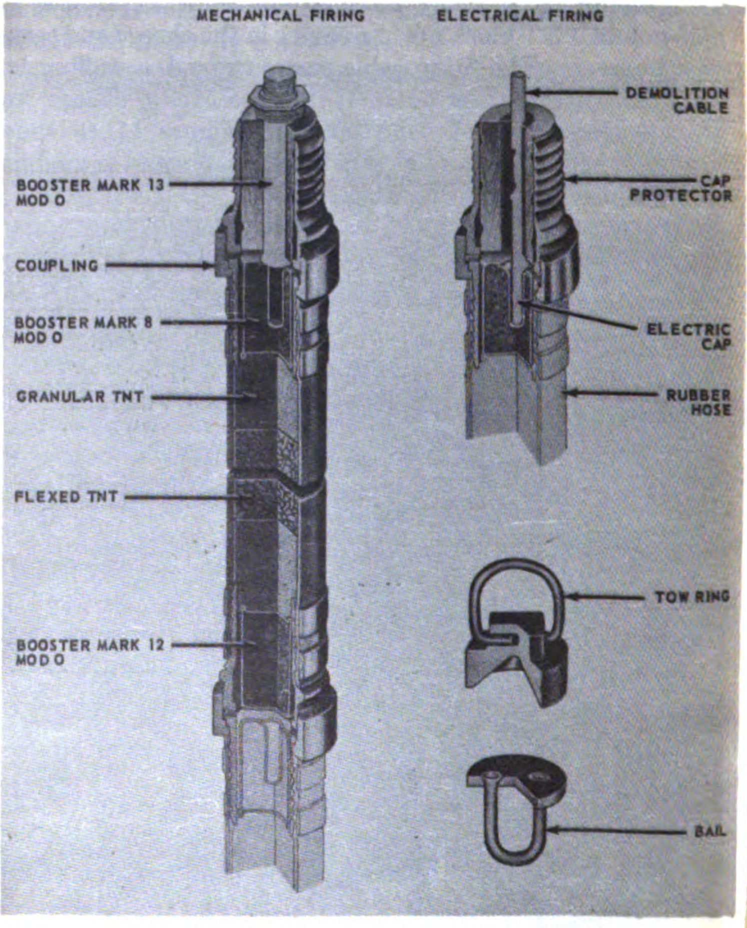


Figure 11–16.—Demolition charge Mk 8 Mod 0.

you can use two or more lengths as a single charge. You can fire the charge electrically; by adding a Mk 13 booster, you can use a mechanical firing device.

Bangalore torpedo M1. This is a metal tube 5 feet long, containing about 9½ pounds of amatol. At each end is a threaded activator well, surrounded by a crystalline TNT booster. They are useful for clearing paths through wire and mine fields, or for any other work where you need a long, narrow charge. The torpedoes come in kits which include connecting sleeves for coupling several of them into a single elongated charge.

Cable and Chain Cutter

Cable and chain cutter Mk 1 Mod 1. This device (fig. 11–17) is worth some special attention because it is useful ashore, afloat, and even underwater (down to 20 feet) for cutting cable, chain, or rod up to 2 inches in diameter. It is a one-shot device like any other demolition charge, and it works on the shaped-charge (Munroe effect) principle. As you remember, you can utilize this effect to increase the penetrating power of a high explosive; all you do is mold the explosive so that there is a space (usually conical or wedge-shaped) surrounded by explosive facing the material to be penetrated. (Fig. 11–17, *B*.) Briefly, here is how you set up the cutter for use:

1. Unwrap the cutter and inspect for proper assembly and for adequate spring clamp tension.
2. Remove the four cotter pins to open the side covers.
3. Pack the cavity tightly with composition C2 or C3. Be sure to get it into the corners of the V liner so the cavity will have the proper shape, and fill it all the way to the top and around the activator well. Then close the covers and secure them with the cotter pins.
4. Be sure the activator well is clean and clear of obstructions. Then prime with either special nonelectric or special electric blasting cap, using a priming adapter and sealing compound to make the joint waterproof. (Details on the

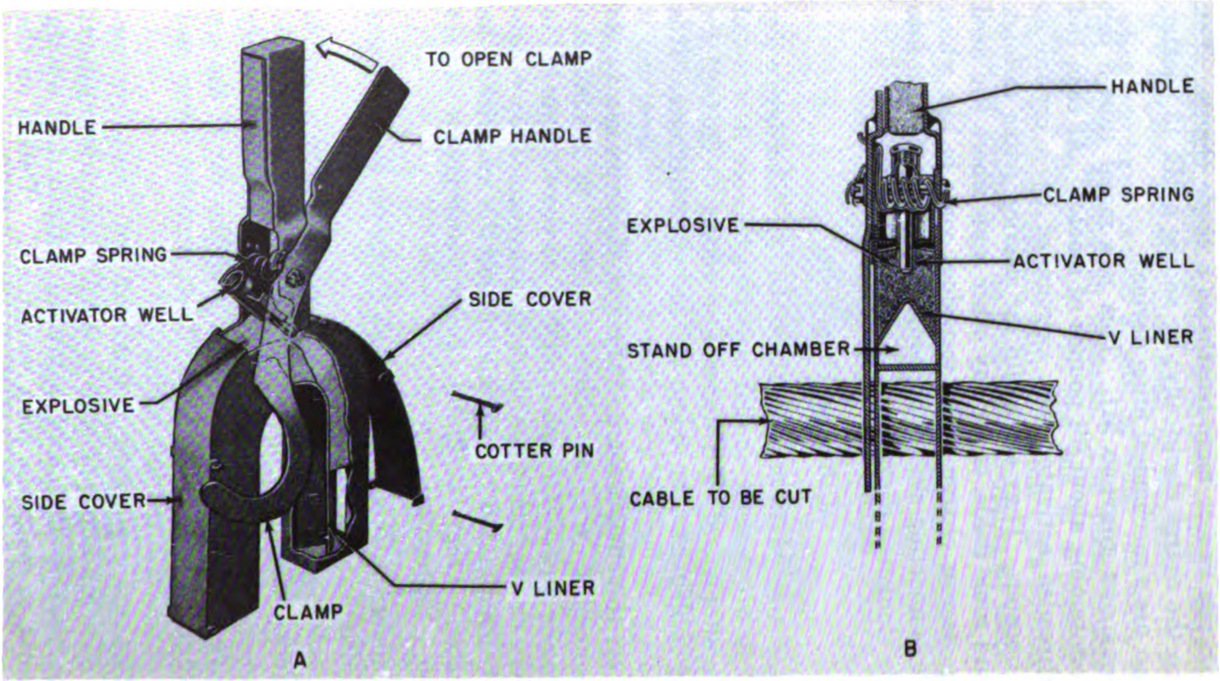


Figure 11-17.—Cable and chain cutter Mk 1 Mod 1. A. General view (partly cut away). B. Cross section showing V liner, stand-off space, and explosive.

procedure for priming charges with these caps are given later in this chapter.)

5. Now attach the cutter to the obstacle to be severed. Open the clamp by pushing the clamp handle toward the cutter handle, slip the open end of the cutter over the cable (or chain or rod) to be severed, and release the clamp handle so that the clamp hooks the cutter on. Light the fuse (if a nonelectric cap and time fuse are used) and clear out. Or (if an electric cap is used) just clear out.

For further details on this cutter, see OP 1571.

CRIMPER AND TESTER

In working with demolition explosives you will use not only ordinary tools but at least one special tool and one special electrical measuring instrument. We shall take up these two now.

Cap Crimper

The most often used special tool in demolition work is the CAP CRIMPER. This tool (fig. 11–18) resembles a pair of pliers in appearance, but must NEVER be used as pliers. Here is what it is designed to be used for:

1. The M2 cap crimper outer jaws are designed to squeeze the shell of the nonelectric blasting cap so as to form a bead around the shell. This water-resistant bead grips the time fuse or primacord (as the case may be) so that it will not come loose, but not tightly enough to interfere with the burning of the fuse. Earlier model crimpers merely formed a sleeve around the shell. On both new and old types a stop on one leg prevents crushing of the shell.

2. The inner section of the jaws will cut time fuse or detonating cord cleanly. NEVER use these cutting jaws for cutting wire. Keep the cutting jaws clean; bits of PETN or black powder on them are dangerous.

3. One leg of the crimper is pointed for punching holes in dynamite cartridges. The other leg terminates in a screwdriver blade.

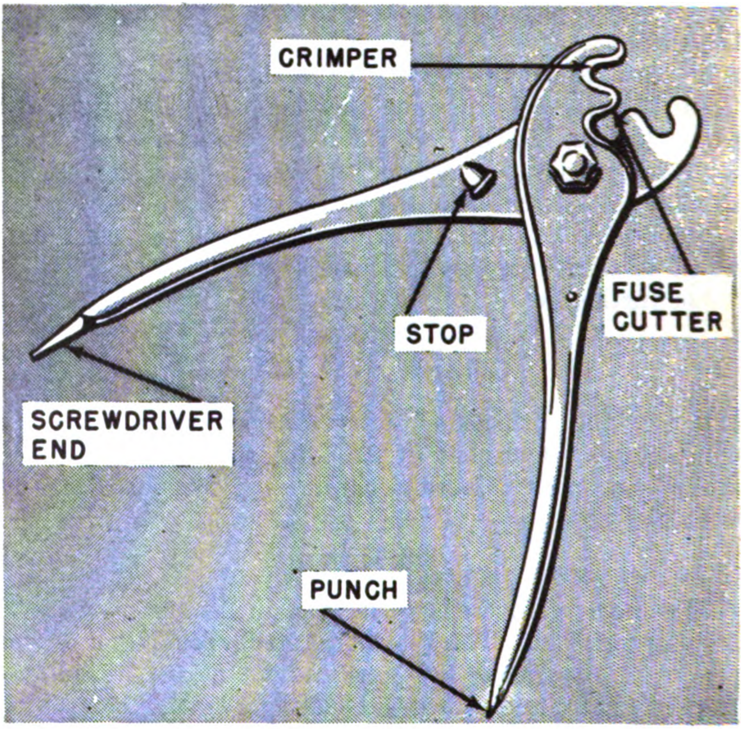


Figure 11-18.—Cap crimper M2.

Blasting Galvanometer

The blasting galvanometer (fig. 11-24) is actually a circuit tester, since it includes not only a galvanometer but a source of electric current—a small silver-chloride cell. The outfit is assembled in a leather case. At the bottom of the case are the two terminals you use to test your firing circuit.

After your circuit is wired up, and just before you're ready to fire, you momentarily touch the ends of the firing wire to the terminals of the circuit tester. If the galvanometer needle swings across the dial you have a closed circuit, and you can go ahead and fire. If the needle doesn't move, your circuit is open, and you'll have to find the trouble.

NEVER try to use ANY other circuit tester or ohmmeter for testing an electric firing circuit. The current output from the blasting galvanometer is too small to fire an electric blasting cap, but the current from an ordinary ohmmeter may be strong enough to fire the charge unexpectedly.

FIRING WITH CAP AND FUZE

In this section, we're going to give you some general directions for using nonelectric blasting caps, crimped onto time blasting fuses, to fire demolition charges. Under some combat conditions this is the best way to fire a charge; the materials you need are light, and you can assemble them quickly. And you can make up your demolition assemblies in advance, before you get to the scene of action.

But of all the usual ways to set off a demolition charge, this one is probably the most dangerous. For one thing, there's always danger of a premature explosion, or a hangfire. For another, you have to make your getaway while the fuse is burning, and there's always a chance that you may stumble.

If possible, it's a good idea to use a mechanical device (such as the demolition firing devices Mk 12 and Mk 15), rather than blasting fuse. That will minimize the chance of a hangfire or a premature explosion.

Always use the electric firing system when you have the necessary time and equipment. It's by far the safest.

Characteristics of Blasting Fuse

The Bureau of Ordnance provides the naval forces with a water-resistant blasting fuse that burns at the rate of about 40 seconds a foot.

But as we told you earlier, there are some foreign detonating cords that look like blasting fuses. They aren't easy to detonate with a flame, but it can sometimes be done. So always test a sample before you try to use it. And for your first test, be sure there's a shield of some kind between your body and the sample you're testing. Use a fuse lighter, with a long pull wire.

If you're sure it's a time fuse you have, test it to see how easy it is to light, and how long it burns. First, cut a piece several inches long from the exposed end of the roll, and discard it. Then, for your test, cut off several accurately measured 2-foot lengths. Use an M2 fuse lighter, if you have one. Carefully measure the time from the instant you operate the lighter to the instant a spurt of flame comes from the other end of the fuse. (If you don't have an M2 lighter, use a match. We'll tell you later how to do it.)

Record the SHORTEST burning time for any of your samples. Use that burning rate for your future calculations. And remember that the burning time was for TWO feet of fuse—not one.

The rate at which a fuse will burn depends partly on the altitude, and partly on how much the fuse is confined. Handling, or exposure to moisture, can change the burning rate. If you're going to use 2 feet or more of fuse, you can estimate its burning time from your previous tests. But that's PROVIDED the altitude and confinement are about the same. If they aren't, make a new test. And if your last test was more than a few days ago, or if there's a chance that moisture or handling may have changed the burning rate, make a new test.

If you're going to use less than 2 feet of fuse, it isn't safe to estimate burning time. Make a special test, using a sample fuse of the actual length you plan to use for the demolition charge. Lay it out under the same conditions you'll use for the actual charge, and light it the same way. Make your test as near as possible to the actual scene of demolition, but not dangerously close to the charge.

There have been many accidents in blasting with fuse and caps. Nearly all of them can be traced to a single cause—a bad guess about the burning time of the fuse. Safety fuse is packed with loose grains of black powder. When you handle a fuse, some of the powder is almost certain to sift out from the cut end. If you handle a short length of fuse—say 4 inches—powder can leak out for an inch or two from each end. When some of the powder is gone, the fuse burns faster. That's why a 4-inch fuse can actually burn at twice the estimated rate.

To keep out of trouble, remember these rules:

1. Unless combat conditions make it impossible, always use at least 2 feet of fuse.
2. If you must use less than 2 feet of fuse, test the burning time of an equal length of fuse under the same conditions.
3. Before you cut a length of fuse, either for a test or for detonating a charge, cut a 2-inch length from the open end of the coil and throw it away.

Equipment for Cap and Fuse Firing

Assemble all the equipment you'll need BEFORE you try to place the charge. Here's a checklist of what you'll need.

1. Demolition blocks or charges
2. Nonelectric blasting cap
3. Time blasting fuse
4. Cap crimper (if the crimper's cutter blades aren't in good condition, you'll need a sharp knife too)
5. Cap sealing compound (if you need extra water resistance)
6. Fuse lighter M2, if available
7. Priming adapter M1 (if the charge has a threaded activator well)

Preparing the Cap and Fuse for Use

Here are directions for preparing the cap and fuse. The best way to prevent accidents is to follow these directions exactly.

1. Cut off a short length from the end of the fuse coil, and throw it away.

2. If you haven't tested the fuse burning rate recently, make a new test with a 2-foot length. If you're going to use less than 2 feet of fuse, make a test with the length you expect to use.

3. Cut off the desired length of fuse. If the cutting edges of the cap crimper aren't keen, use a clean sharp knife. Cut the fuse square across—not at an angle.

4. Now, if you're going to use a priming adapter, push one end of the fuse through the hole at the flat end of the adapter.

5. Examine both ends of the fuse, to be sure no powder has sifted out. The powder should be flush with the end of the fuse.

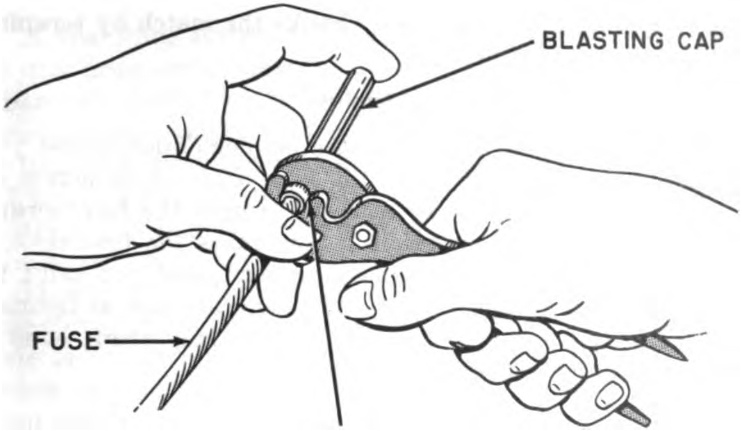
6. Take one nonelectric blasting cap from the box. Be careful; it's more dangerous than it sounds. Tilt the cap box slowly into the palm of your hand, until one cap starts to slide out. Withdraw this cap carefully. Never use a stick, or a pointed instrument, to pick caps out of the box.

7. Examine the cap for dirt and moisture. If there's dirt in it, blow lightly into the open end. If that doesn't get the dirt out, use another cap. If you see moisture in the cap, use another one.

8. Now, gently but firmly, push the end of the fuse into the cap; it will go in about seven-eighths inch. Don't force the fuse if you can't push it in easily. And push it straight—don't twist it. Any friction between the end of the fuse and the detonating compound in the cap is likely to fire the cap.

9. Now you're ready to crimp the cap onto the fuse. (Fig. 11–19.) Hold the fuse between the thumb and third finger of your left hand. Put your forefinger over the end of the cap. Slide your thumb and forefinger up to the open end of the cap to guide the crimper. Crimp close to the open end; crimping near the explosive may detonate the cap. If you use your thumb and third finger to guide the crimper, you can crimp a cap properly even in the dark.

(If you're going to put the charge in a damp place, it's a good idea to apply cap-sealing compound to the fuse before you push it into the cap. Spread a little of the compound around the outside of the fuse, at the place where the crimp will be. Don't dip the end of the fuse in sealing compound. Don't let the compound touch the cut end of the fuse, or the detonating compound in the cap.)



PRESS FUSE IN FIRMLY
AND CRIMP CAP ABOUT
$\frac{1}{8}$" FROM END

Figure 11–19.—Crimping a blasting cap onto a time fuse.

10. Now insert the cap assembly in the demolition charge. If the charge has a threaded activator well, you'll be using a priming adapter. Slide the adapter a short distance up the fuse, AWAY from the cap. Insert the cap in the activator well. (It must go in freely; don't force it.) Gently slide the adapter down the fuse, and screw it into the threads of the activator well. Never use the priming adapter to force the cap into the well.

Lighting the Fuse

There are several ways to light the fuse safely. The most reliable is to use the waterproof and dependable M2 fuse lighter. But when you use the M2 lighter, remember that because it's waterproof, it holds in the gas that comes from the burning fuse. That builds up a small pressure, and the first few inches burn faster than you'd expect. So always allow a little extra fuse length when you use the M2 lighter.

If you have no fuse lighter, you can use a wooden match. (Fig. 11–20.) Hold the match head firmly against the powder at the open end of the fuse. Strike the match by scraping the box across its head.

Misfires

Don't try to light a time fuse for demolition unless you know you can do it right the first time. And here's an inflexible rule: After ANY attempt to light the fuse, scram. That rule has no exceptions. Sometimes the fuse smokes when it's burning; sometimes it doesn't, and you can't be sure whether it's lit or not. After any attempt at lighting the fuse, get away to a safe place and stay there, even if you think the fuse isn't burning.

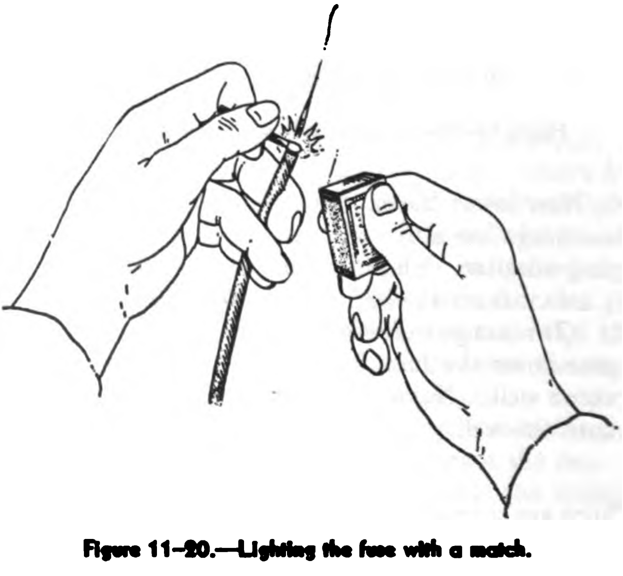


Figure 11–20.—Lighting the fuse with a match.

Wait until the longest estimated burning time of your fuse has elapsed. If the charge doesn't detonate by then, you'll know you have a misfire. Stay in a safe place; WAIT AT LEAST 30 MINUTES before you go back to investigate. (In actual combat, you may have to investigate almost immediately. But in any case wait as long as you can.)

Dual Firing Systems

A dual firing system will decrease the chance of a misfire. A dual firing system uses more than one cap and fuse, or more than one method of firing. If a misfire is likely to leave unrecovered charges hidden, or tramped in the ground, or lying in shallow water, then use dual firing whenever possible. If you use two separate fuses, be sure to cut one of them extra long. Light that one first, so you'll have time to light the second one safely.

During training operations with time blasting fuse, always use a dual firing system if possible. Your best bet is to prime one of the charges with an electric cap, and run the firing wires back to a safe place. Then, if the time fuse misfires, you can detonate the charge electrically without leaving your place of safety.

ELECTRIC FIRING

The electric firing method uses electric blasting caps with firing wires running to a distant source of electricity (usually a blasting machine).

Electric firing is the safest method you can use. You control the detonation from a safe distance; you don't have to make a getaway from the vicinity of the charge; you don't have to make any guesses about burning time. And, if you disconnect the blasting machine from the firing wires, it's safe to investigate a misfire immediately. There's no danger of a hidden ember smoldering inside the fuse.

The basic principle of electric firing is simple. When an electric current flows through a conductor, it generates heat. The amount of heat generated at any point depends on three things: the voltage drop at that point; how much current flows; how long the current flows. So, for successful electric blasting, you'll have to be sure that your source of electricity is powerful enough to fire all the caps you've wired in the circuit. And you'll have to make the resistance of your firing wires and splices as low as possible. That will leave most of the resistance, and most of the voltage drop, in the bridge wires of the caps.

Equipment for Electric Firing

Here's a checklist of the equipment you'll need for electric firing.

1. Demolition blocks or charges
2. An electric blasting cap
3. Approved firing wire or demolition cable
4. A blasting machine
5. A sharp knife
6. Friction tape
7. A priming adapter for charges with threaded activator wells
8. A blasting galvanometer

Electric Blasting Caps

For service use, the Bureau of Ordnance issues Army Engineer special electric blasting caps. These caps are waterproof. Their leg wires are enameled except at the ends, where they're tinned. The tinned ends are twisted together, and secured by a metal shunt. The shunt is a safety device. It short-circuits the leg wires, so the cap can't be fired accidentally by stray electric currents or static charges. For your own protection, leave the shunt in place until the last minute. Don't remove it until you're ready to wire the cap into your blasting circuit.

Since the Army Engineer special electric caps have a base charge of 13⅓ grains of PETN, they're more powerful than any commercial blasting cap. Some of the explosives you may use, like composition C2, or C3, are fairly hard to detonate, and commercial caps won't detonate them. So, for demolition work, use only the special caps. The Bureau of Ordnance issues two kinds of commercial caps for other purposes, though not for demolition. You can tell them from the special caps by their size. Here's a table that compares the dimensions of the three kinds of caps issued by the Bureau of Ordnance.

The Bureau of Ordnance issues special electric blasting caps made by three different manufacturers. (Fig. 11–21.)

	No. 6 commercial	No. 8 commercial	Engineer special
Length, inches	1⅜ to 1⅝	1⅝ to 2¼	3
Diameter, inches	0.273 to 0.275	0.273 to 0.275	0.275

In each of these brands, the bridge wire has a different resistance. For that reason, use only ONE brand of cap when you're wiring two or more caps in series. If you mix them up, one cap may fire before the others, opening the circuit and leaving the other charges unfired. You can tell the three brands apart by the color of the shell, and by the kind of shunt on the leg wires.

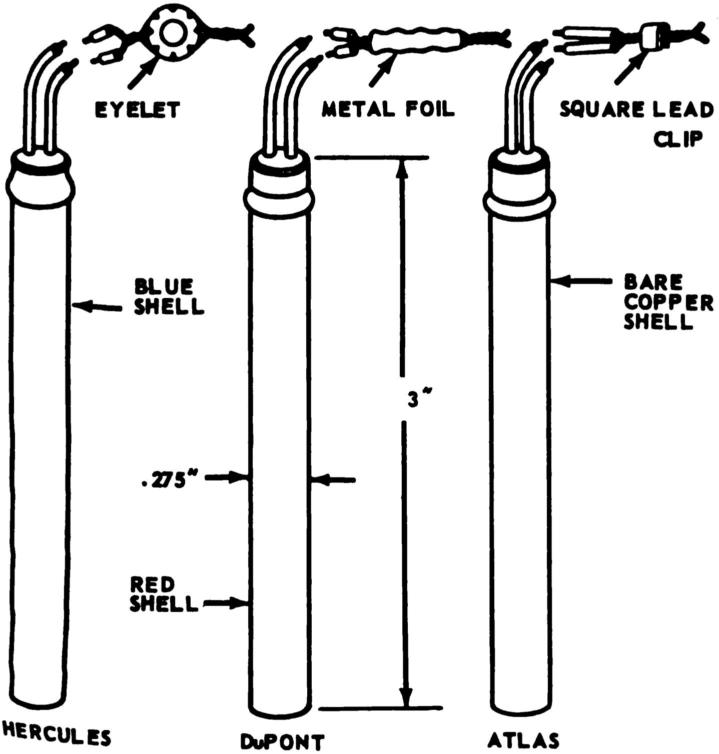


Figure 11–21.—Brands of electric blasting caps.

Using Priming Adapters with Electric Blasting Caps

If you're using charges with threaded activator wells, use a priming adapter to hold the cap inside the charge. First, slip the two leg wires of the cap through the slot in the adapter. Gently insert the cap in the activator well, without forcing it. Then screw the priming adapter into the threads of the activator well.

SAFETY NOTE. If you pull one of the leg wires out of an electric cap, it may explode. So never put a strain on the leg wires. If the wires won't go easily into the slot of the priming adapter, don't use the cap to pull them through. Instead, grasp the wires several inches from the cap. Slide the adapter slot along the wires, moving the adapter AWAY from the cap. If that doesn't work, try it again, tilting the adapter so that the wires enter one end of the slot first.

Electric Wiring

Poor electric connections in a demolition circuit are likely to cause misfires. For that reason, ONE person who thoroughly understands electric firing circuits should be responsible for ALL wiring. He should make all the splices himself. These are the main points to look for:

1. Be sure that all the caps are included in the circuit.
2. Be sure that all the splices between cap wires, connecting wires, and firing wires are properly made.
3. Be sure there's no chance of a short circuit. Carry the handle of the blasting machine in your pocket. That will reduce the possibility of accidental firing while you're near the charge.
4. When wiring up a circuit, make sure there's no strain on the leg wires that might pull them out of the caps. Be especially careful when the firing wire is partly unsupported, or where it passes through water and may be moved by wave action. If necessary, tie the firing wire, or the leg wire, or both, to the charge.

If you're going to splice two insulated wires, strip off about 3 inches of insulation from the end of each wire. Be sure to remove the enamel, as well as the other insulating material. Clean the bare wires by scraping them lightly with the back of a knife blade. (But don't cut or weaken them.) If the wire is stranded, twist the small strands together to make a single lead.

To splice (fig. 11–22), join the two wires with several twists, bend the free ends toward each other, and twist them together to make a "pigtail." Then bend the pigtail to one side, so it will lie along the wire.

If there's any chance that your splice will touch the ground, or some other conductor, insulate the splice by wrapping it with friction tape. If you have no tape, support the splices on a dry stone or dry piece of wood. (But if you're going to tramp moist earth over the splice, tape is essential.)

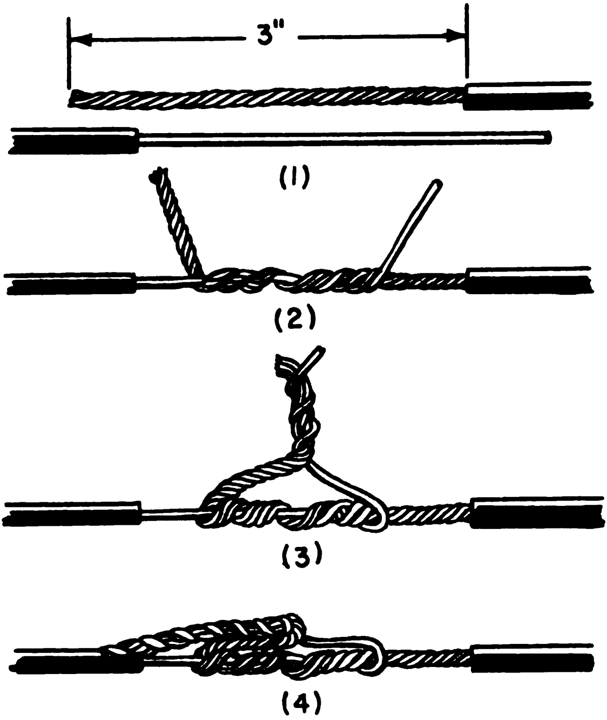


Figure 11–22.—A method of splicing wires.

If you're going to splice two pairs of wires together, stagger the splices so they can't touch each other, and bind the two wires together with cord or tape.

Firing Circuits

When you're going to fire two or more charges electrically, you will usually wire them in series. You splice one wire from the cap in the first charge to one wire of the cap in the second charge, and so on through all the charges, until only the two end wires are left. And you splice these to the firing wires that lead to the blasting machine. (Fig. 11–23.)

Caution: Stray electric currents or static charges in the firing wires have sometimes caused premature explosions. You can be safe from this kind of accident only if you short out any stray currents. Twist the bare ends of the firing wires together, at each end of the cable. Don't separate the wires at the firing end until you're ready to splice them into the circuit. And don't separate the wires at the reel (input) end until the rest of the circuit is completely wired, everybody is out of the danger zone, and you're ready to blast.

Figure 11–23, *A*, shows the usual way to wire up a series circuit. One of the wires from the cap in one charge is spliced directly to a wire from the cap in the next charge. Of course, if the cap wires aren't long enough to meet, you'll have to use another piece of wire between them. Use the "leapfrog" series circuit (fig. 11–23, *B*) when you're going to detonate a number of charges laid out in a line. It has the advantage of eliminating a long return line from the charge at the end of the series to the firing wire.

How many caps can you wire up in one circuit? That depends on the resistance of the circuit, and on the strength of your electric power source. Don't put too much stock in such designations as "10-cap blasting machine" and "50-cap blasting machine." Those names apply to "average" conditions. If your circuit has more than normal resistance,

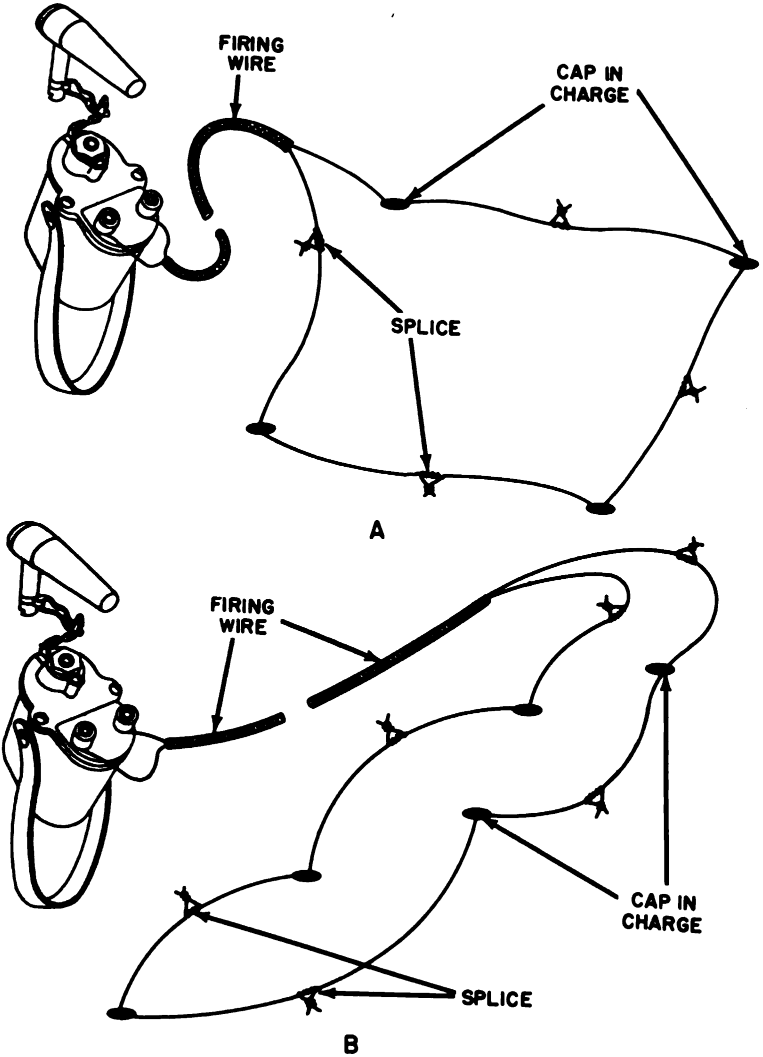


Figure 11-23.—Series circuits. A. Common type. B. Leapfrog type.

because of poor splices or extra long wires, the blasting machine can't live up to its designation. And if your blasting machine isn't strong enough for the circuit you've wired up, you're bound to have misfires.

Charges can be wired in parallel or in series-parallel, but both these types of circuits take a lot of power. You can use them when you have access to a power or lighting line for firing, but they won't work with a blasting machine. Besides, you have to match the resistance of all the parallel branches, so you'd better not try these circuits unless you're a wiring expert.

Testing the Circuit

You can't tell, just by looking, if you have an open circuit or a short circuit. Before you try to fire a charge electrically, always test the circuit with a blasting galvanometer.

First, test the galvanometer itself. Connect the two terminals by holding a piece of metal across them. The galvanometer needle should show at least half-scale deflection. If it doesn't, the cell is weak and must be replaced.

If the galvanometer is OK, test the firing wire. There isn't much point in testing it while it's on the reel; broken wires may make contact on the reel, but separate later. Test the firing wire AFTER you've laid it out in its final position, but BEFORE you connect it to the charges or the blasting machine.

First, test the firing wire for short circuits. Touch the two wires at one end to the terminals of the galvanometer. The needle should NOT move. If it does, the two firing wires are making a short circuit. You'll have to find the short and fix it.

To test for a broken wire, twist the two wires together at one end. Touch the wires at the other end to the terminals of the galvanometer. The needle should show a wide deflection. If it doesn't move at all, you have an open circuit. If it moves just a little, there's a point of high resistance somewhere in the wire.

After you've repaired all breaks and short circuits, test it again.

When you've connected the firing wires to the end wires from the charges, test the circuit as a whole. Touch the ends of the firing wire—at the reel end of the cable—to the terminals of the galvanometer. The needle should move part-way across the scale. (It won't move as far as it did in the first tests, because of the resistance of the caps.) If the needle doesn't move at all, you have a broken circuit. Here's how you find the break:

1. Look at the firing wire at the reel end; be sure the two wires are separated, and not touching any conductor.

2. Now take your galvanometer to the other end of the firing wire. Connect the first splice on one wire to one of the galvanometer terminals, and the first splice on the other wire to the other terminal. In figure 11–24, these two splices are marked "C" and "D." If the galvanometer needle moves now, it shows that your trouble was in one of these splices.

3. If the needle doesn't move, connect a wire ("N" in fig. 11–24) from splice "D" to galvanometer terminal "L." The wire "N" should be long enough to reach from "D" to any point in the circuit. Touch galvanometer terminal "O" to the next splice. If the needle fails to move, you have trouble

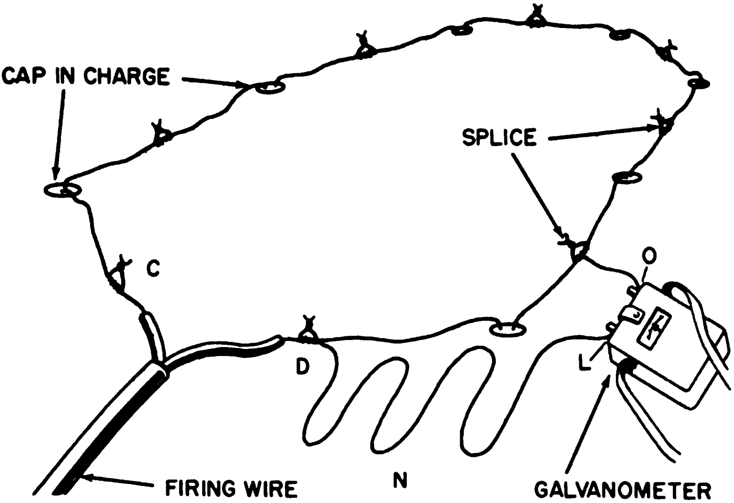


Figure 11–24.—Finding a break in a firing circuit.

either in the splice at "O" or somewhere between "O" and "D."

4. If the needle moves, then take your galvanometer around the circuit. Touch terminal "O" to each splice in turn. (Leave wire "N" connected from "D" to "L.") If the needle moves when you touch "O" to one splice, but not when you touch it to the next one, you've found the trouble: either it's in the second splice, or it's somewhere between the two.

5. If you find a bad splice, open it up and make a good one. If you find a broken wire, splice the two ends together. Then retest the splice.

6. If a defective cap seems to be causing the open circuit, BE CAREFUL. First of all, go back to the reel end of the firing cable, and twist the two firing wires together. Then, if the charge is easy to get at, carefully remove the defective cap and replace it with a good one. If the charge is hard to get at, or if it's covered with tamping, handle it as a misfire. Don't try to dig away the tamping, and don't try to drag the charge out by pulling on the cap wires. Your best bet is to disconnect that charge from your circuit. Place a new charge within one foot of the defective charge. Prime the new charge, and wire it into the circuit in place of the other one. When it detonates, it will detonate the defective charge.

7. After you've finished your repairs, take the galvanometer back to the reel end of the firing wires. Unshort the wires, and give the whole circuit a final test.

Firing with the Blasting Machine

When your final test shows a complete circuit, replace the handle on the blasting machine. (You've been carrying the handle in your pocket, as a safety measure.) Operate the handle a few times to free up the machine, and to be sure it's in working order. Make one final, careful check to be sure there's nobody in the danger zone. Then loosen the nuts on the blasting machine. Connect one of the firing wires to each terminal, and tighten the nuts.

To fire the charge, operate the handle vigorously. The blasting machine doesn't apply its power to the circuit until the handle reaches the end of its stroke. To be sure it's moving fast when it reaches the end of its stroke, turn it with your full strength.

Firing with Other Sources of Electricity

If you use batteries to power your firing circuit, be sure they're in good condition. Use fresh dry cells, or freshly charged storage batteries. Don't depend on batteries for firing power unless you know for sure they're strong enough for the job. That's something you learn from experience.

The use of alternating current for blasting is a complicated subject, and we won't go into it here.

Electric Misfires

If the charges don't fire on your first attempt, try again. Turn the handle of the blasting machine harder, or use a bigger machine. If you're using batteries, add more batteries in series.

If the charge still won't fire, you'll have to investigate. First, if you're using batteries, disconnect them and carry them away from the firing wire. If you're using a blasting machine, disconnect it; take the handle off and put it in your pocket. Twist the ends of the firing wire together. Then you can look for the trouble.

But this applies ONLY if electric firing is the only method you're using. If you have a dual firing system, and have an electric misfire after another misfire, wait a full 30 minutes before you go near the charges.

FIRING WITH MECHANICAL FIRING DEVICES

By "mechanical firing device," we mean a device that uses friction or percussion to give a flash of flame. The term doesn't include electric firing devices. A mechanical firing device is especially useful if you have to place a charge fast when there is no time to wire up an electric circuit, or lay out a time fuse.

In this section we'll discuss four devices:

Firing device Mk 12 (figure 11–9)
Firing device Mk 15
15-second delay detonator M1 (figure 11–10)
8-second delay detonator M2

All these devices are more reliable than blasting fuse. They're designed to minimize the chance of a hangfire or a premature explosion.

The Bureau of Ordnance issues still other firing devices for special purposes. You'll find them described in OP 1178 (first revision).

Don't try to use any mechanical firing device until you've been trained in its use, and until you thoroughly understand all the special safety precautions that apply to it.

Demolition Firing Devices Mks 12 and 15

You can use either the Mk 12 or Mk 15 firing devices to fire standard demolition charges with threaded activator wells. Follow these steps:

1. Remove the packing tube. Handle the device carefully; remember that it contains a clockwork mechanism.
2. Screw the coupling base into the end of the firing device. (Sometimes the coupling base will be screwed in place on the firing device when you get it.) If there's a plastic protective cup over the snout of the coupling base, remove it.
3. Take a special nonelectric blasting cap from the cap box. (Use all the precautions we told you about earlier in the chapter.) Inspect the cap for dirt and moisture.
4. Fit the open end of the cap over the rubber sleeve at the end of the coupling base. Gently push the cap as far as it will go. Don't twist it.
5. Crimp the cap to hold it in place. Use the cap crimper M2, and crimp near the open end of the cap, just as you would with time fuse.
6. Inspect the activator well of the charge, to be sure there's no dirt in it. Then screw the complete firing device assembly into the charge, gently but securely.

7. Now set the firing device for the delay you want. Turn the head of the device until the desired time is opposite the line above "delay in seconds" (on the Mk 12) or "hours" (on the Mk 15). The head may be a little hard to turn, because of the waterproof packing. You may have to use a little force, but don't try to turn past the stop pin. After you've set the delay, be sure the head has enough friction to hold it in place. Unless it's very hot or very cold, the firing device will operate within 5 percent of the time you set. (The error may be more than that at the lowest settings.) In choosing the delay time, always give yourself enough time to get away to a safe distance. And give yourself an extra margin of safety, if you possibly can.

8. Now, gently place the charge where you want it to go off. (This is where the mechanical firing method has an advantage over the others for combat demolitions. You can assemble the charge and set the time delay in a safe place. Then you can run to the point of demolition, place the charge, pull the pin, and run back, all at top speed.)

9. When you place the charge, leave enough space around the arming pin to let it move out three-eighths of an inch. Now, unless you're actually under fire, take a few seconds for safety. Look back over the ground where you'll make your get-away, to see if there's anything you might stumble over. Take another look at the head of the firing device, to be doubly sure it's set for the delay you want. Then pull out the cotter pin, and run.

> ***Caution:*** After you pull the pin, do not try to re-set the time delay. After the device starts, there's NOTHING you can do to stop it. Just get away fast.

Fifteen-Second Delay Detonator M1

We described this device earlier in the chapter. Figure 11–10, *D*, is a picture of it. The detonator M2 is very much like the M1, except that its delay is only 8 seconds. To use either of these detonators, follow these steps:

1. Remove the cap protector from the detonator.

2. Look into the activator well to be sure there's no dirt in it.
3. Gently but securely, screw the detonator into the charge.
4. Place the charge where you want it to detonate. Look over your get-away route, to check for obstacles.
5. Remove the safety pin.
6. Vigorously pull out the ring, and get away FAST. There's nothing you can do to stop the detonator, once it's started. In 15 seconds (with M1) or 8 seconds (with M2), the charge will explode.

FIRING WITH DETONATING CORD

Detonating cord is useful when you want to fire a great many charges at the same time. (For a limited number of charges electric firing is better. But the more charges you have, the more complicated your circuit will be, and the harder it will be to test.) Detonating cord can be used in combat, but the cord may detonate if a bullet hits it. So, if possible, use some other firing method for combat demolitions.

Characteristics of Detonating Cord

Detonating cord is waterproof, except at its free end. If you apply sealing compound to the end you can use the cord under wet tamping, or even under water. (But in surf the waterproof coating will gradually wear away after about 3 hours.) You can splice two cords by tying them together; the cord will stay waterproof for about 24 hours if you leave a 6-inch free end on each cord, beyond the splice.

When you detonate the cord, a wave of explosion travels down its length to the charge. You can tie branch lines onto the main cord and a wave of detonation will be transmitted to each of the branching cords. To detonate the cord you can use an electric cap, a nonelectric cap, or a detonating cord initiator. But you must have some time delay at the firing point—time fuse with a nonelectric cap, for example. Or you can run firing wires from an electric cap. REMEMBER

THIS: there's NO delay in the primacord itself; the wave of detonation travels down the cord at about 4 miles a second.

Here are some more points to remember:

1. When you unwind the cord from its spool, it tends to form a spiral. Straighten it out before you connect it to the charge. If the cord loops, the detonation of one part might cut the other in two, without detonating it. Lay the cord lines as straight as possible, but don't stretch them taut.
2. Avoid kinks or sharp bends in the cord.
3. Don't remove any part of the fabric covering, for any reason.
4. In cold weather, the cord tends to get more brittle. Handle it with extra care, to keep from cracking the fabric cover or breaking the explosive train.

Detonating Cord Connections

After you've planned your cord layout, run your main cord to its charge. Tie on branch lines leading to other charges. Let branch lines run out at a right angle to the main line, or let them run forward in the direction the detonation wave will travel. But don't let them lead back toward the cap end of the main line.

To fasten a branch line to the main line, use a GIRTH HITCH. Figure 11–25 shows how to tie it. Leave a free end at least 6 inches long, to protect the connection from moisture.

To connect two cords end-to-end, tie a square knot and pull it tight. If the knot will be under water, or if you're going to cover it with earth, make it extra tight. Don't forget to leave 6 inches of each cord free beyond the knot.

You can connect any number of branch lines to the same main line, but never more than one at any one point. (That's to keep one line from breaking another without detonating it.) And never tie on a branch line at a splice in the main line.

Firing Primacord with Blasting Caps

You can use either an electric or nonelectric cap to detonate primacord. If you use a nonelectric cap, insert the proper

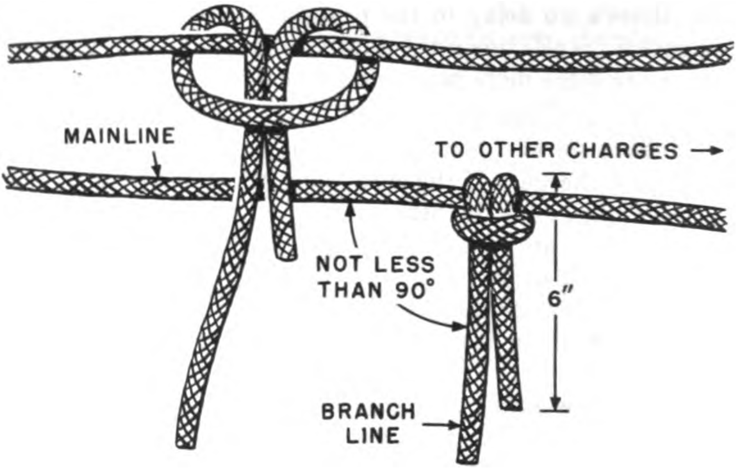


Figure 11–25.—Connecting a branch line with a girth hitch.

length of time fuse, and crimp the cap on the fuse before you attach the cap to the primacord. Hold the cap parallel to and against the cord, with its CLOSED end pointing toward the charge. Leave at least 6 inches of cord free at the other end of the cap. Tape or tie the cap firmly in place against the cord.

Then fire the cap in the same way (and with the same precautions) you'd use if it were attached to the main charge.

Firing Primacord with the Initiator Mk 2 Mod 0

You can also use a cap to fire primacord by using the initiator Mk 2 Mod 0. (Fig. 11–6.) Figure 11–26, *A*, shows how to attach the initiator to the cord. Grasp the cord firmly in both hands. Lay it across the slot at the end of the initiator. Press the initiator into place with your thumbs. The cord won't stay in place, and it won't detonate, unless you force it into the initiator as far as it will go.

To assemble the initiator for firing with an electric cap (fig. 11–26, *B*), follow these steps:

1. Unscrew the priming adapter from the end of the initiator. Inside, you'll find a paper tube. Take it out and discard it.

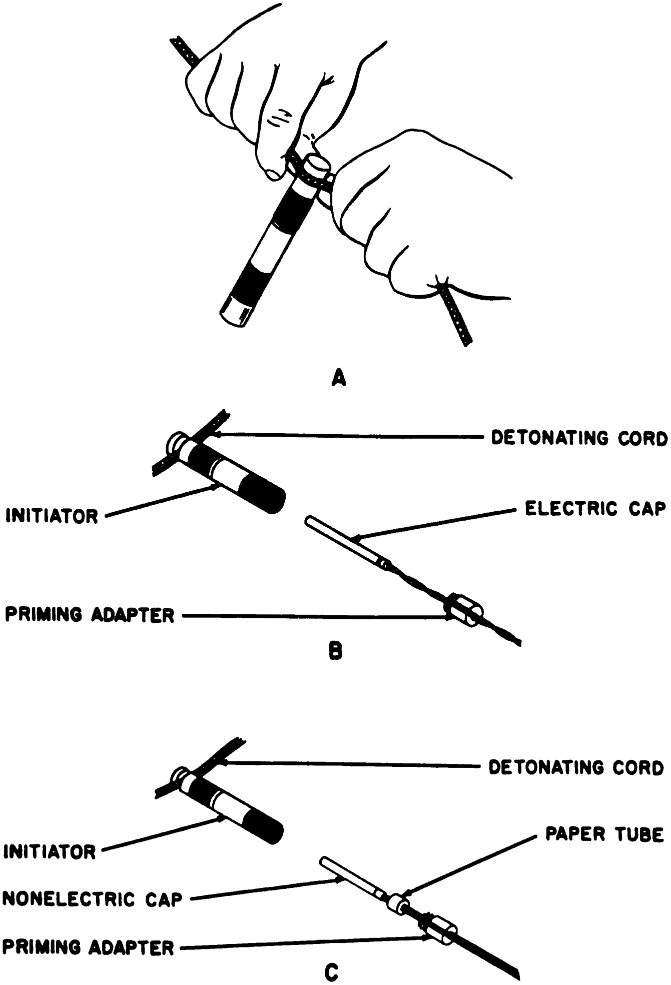


Figure 11–26.—Using the detonating cord initiator. A. Forcing initiator onto detonating cord. B. Assembling initiator to electric cap. C. Assembling initiator to nonelectric cap.

2. Remove a special electric blasting cap from the cap box and thread its lead wires through the slot in the priming adapter.
3. Gently push the cap into the initiator. Screw the priming adapter into place.
4. Tie the leg wires around the knurled part of the initiator with a half hitch, to prevent straining the wires where they enter the cap.

To assemble the initiator to a nonelectric cap (fig. 11–26, *C*):

1. Unscrew the priming adapter, and take out the paper tube.
2. Push the end of the time fuse through the hole in the priming adapter, and through the paper tube.
3. Crimp a special nonelectric blasting cap on the end of the fuse.
4. Carefully insert the cap and paper tube in the initiator, and screw in the priming adapter.

You can also use the initiator with a Mk 12 or similar type of firing device. Here is how to set it up:

1. Remove the packing tube, and screw the coupling base into the end of the firing device, if it is not already assembled. If there's a plastic protective cup over the snout of the coupling base, take it off.
2. Packed with the initiator is an extra rubber gasket. Slip it over the coupling base.
3. Unscrew the initiator head from its cap holder, and screw the head over the end of the coupling base. Turn it up tight, so the gasket will make a waterproof seal.
4. Snap the initiator onto the main line of detonating cord.

On the top of the firing device is a lashing eye. You can pass a line through the eye to lash the assembly in place.

You can follow this procedure with any firing device that has a coupling base. But with the 15-second delay detonator M1, or the 8-second delay detonator M2, don't unscrew the initiator head from its cap holder. Just screw the detonator into the cap holder.

PRECAUTIONS

You don't have to be told that blasting is dangerous business. That's why you'll get special training before you're actually assigned to demolition work. And that's why you have a long list of precautions to study. It's no fun to read a long list of sentences that all begin with "Don't." But study them carefully just the same; they may save your life.

Memorizing a list of rules won't ensure complete safety. Nobody could make up a list of precautions to cover every possible situation. So use your head. Here's a rule to remember: Always handle explosives the way you'd handle eggs if there were a death penalty for cracking a shell.

You'll notice that the precautions are divided into two separate lists. First are the "reliability" precautions, to help make sure your demolition charges will really go off when you want them to. The other is a list of safety precautions, to help make sure they don't go off BEFORE you want them to.

Precautions to Ensure Reliability of Firing

1. Don't store explosives in a damp place.
2. Use only the ARMY ENGINEER SPECIAL blasting caps for military demolitions. Weaker caps may cause misfires.
3. Don't try to light a time fuse unless you're sure you can do it right on the first try.
4. Cut blasting fuse square across—never on a slant.
5. Before you cut a length of time fuse, cut off a 2-inch piece and throw it away, unless you KNOW the fuse has been cut within the preceding hour or two.
6. Don't twist a time fuse; don't let it kink or bend sharply.
7. Push the end of the fuse all the way into the cap, so it touches the initiating compound.

8. Don't dip the end of the fuse in sealing compound. That makes a barrier between fuse and initiating compound, and will probably cause a misfire.
9. Inspect the inside of the cap for moisture. If you see any sign of dampness, use another cap.
10. Crimp the cap onto the fuse with an M2 cap crimper, or some other crimper that gives a continuous indentation all the way around the shell. Never use any other tool.
11. All the wiring in an electric firing circuit must be the responsibility of ONE person—who knows his job thoroughly.
12. In any one electric firing circuit, use only one brand of electric blasting cap.
13. Before firing, be sure to remove the safety shunt from electric caps.
14. Test your electric firing circuit with a blasting galvanometer. You can NOT tell, just by looking at the wire, whether your circuit is complete.
15. When it's time to operate the blasting machine, don't be timid about it. Use your full strength.
16. Handle clockwork delay firing mechanisms carefully, to protect them from damage.
17. When you attach a firing device to an activator well, screw it in securely.
18. When you use the initiator Mk 2 Mod 0 with a coupling base, don't forget to insert the extra rubber gasket. Then screw the initiator head tightly into the coupling base, to make a watertight seal.
19. Don't let a line of detonating cord lie kinked or looped. Straighten the detonating cord as you unwind it from the spool, but don't stretch the line taut.
20. Attach branch lines of detonating cord at right angles to the main line; or let the branch lines run forward, in the direction the wave of detonation will travel. Don't let them run back toward the cap end of the main cord.

21. When you tie lines of detonating cord, leave at least 6 inches of cord free beyond the knot.
22. If the knot will be under water, or exposed to surf, make it extra tight.
23. Don't remove any part of the covering from a detonating cord.
24. Protect the cord from unnecessary exposure to water and surf.

Safety Precautions

1. When your explosives and demolition equipment aren't in use, keep them locked up. And don't let irresponsible people get hold of the key.

2. Any demolition project must be under the supervision of ONE person, who really understands the job. Never divide the responsibility.

3. Don't smoke near explosives. And don't let any one bring an open flame into the vicinity.

4. Don't leave caps or explosives exposed to direct sunlight, or any other source of heat.

5. Don't experiment with blasting caps, or try to open them. Don't try to remove a cap from a cord or fuse after it's been crimped on (except by cutting the cord or fuse).

6. Keep blasting caps in their box, and keep the box covered. Never carry caps loose in your pocket.

7. Don't try to remove a cap from the box by picking at it with a wire or nail, or any other instrument. Tilt the box toward your hand until one cap starts to slide out; then withdraw that one cap very carefully.

8. Since blasting caps contain initiating compound, they're extremely sensitive. They must be stored in a separate place, well separated from all other explosives. Don't carry caps and explosives in the same vehicle unless it's absolutely necessary.

9. If a blasting cap is assembled with a detonating cord, or with an explosive charge, or both, then for stowage purposes you must treat the whole assembly as a blasting cap with the total strength of all its parts.

10. Before you insert a cap or the detonator end of a firing

device in an activator well, make sure there's no dirt in the well.

11. Gently insert the cap in the activator well BEFORE you screw in the priming adapter. Never use the adapter to force the cap into the well.

12. Use a dual firing system, if you can, whenever there's a chance that a misfire would leave unexploded charges hidden, or tamped in the ground, or unrecovered in shallow water. This rule is especially important during training.

13. Never use a short firing delay unless it's absolutely necessary. No matter what the conditions, never cut a fuse so short that you expect it to burn less than 10 seconds.

14. If you're using less than 2 feet of fuse, be especially careful to protect it from bending and mashing, or any other rough handling. If powder spills from the end of the fuse, the fuse will burn faster.

15. For training, never use less than 18 inches of fuse, unless you're training specifically in the use of short fuse. Then use only small, token charges.

16. Before you use any safety fuse, test its burning rate on a 2-foot sample. If you're going to use less than 2 feet, test a piece the same length you expect to use.

17. Before you put a cap on a fuse, look into the open end of the cap. If you see dirt in the cap, try to blow it out gently. If that doesn't work, use another cap.

18. Don't force a fuse into a cap. Don't insert it with a twisting motion; any friction against the initiating compound may detonate the cap.

19. Crimp the cap close to its OPEN end. Use a cap crimper; never try to crimp a cap with a knife, or with your teeth.

20. When you use a short fuse, tape the connection between the fuse and cap, to ensure that no flame from the fuse lighter enters the cap directly.

21. Don't hold the charge in your hand while lighting its fuse.

22. Before you light a time fuse, be sure there are no other

caps or charges nearby; flame from the burning end of the fuse might set them off.

23. After your FIRST try at lighting a time fuse, scram. Don't wait around to find out if you were successful.

24. When you're using a cap and fuse, or a mechanical firing device, don't investigate a misfire immediately. After the end of the longest predicted delay, wait at least another 30 minutes (unless actual combat conditions make it impossible to wait).

25. Don't pull on the wires of an electric cap, or let anything put a strain on them. If firing wires are partly unsupported or run through surf, tie them so they can't pull the leg wires out of the cap. When you're inserting the cap wires in the slot of a priming adapter, don't use the cap to pull the wires through the slot.

26. Don't connect the firing wires to the blasting machine until you're ready to fire. Instead, keep the ends near the blasting machine twisted together. Don't separate them until you're ready to test the circuit.

27. After you fire a charge electrically, immediately disconnect the firing wires from the blasting machine and twist their ends together.

28. Don't prime or connect charges for electric firing during a thunderstorm, or when it looks like there's a storm on the way.

29. To test an electric firing circuit, use only a blasting galvanometer or circuit tester with a silver chloride cell, never any other kind.

30. Never have any electric wires or cables near blasting caps or explosives except to fire the charge.

31. Don't remove the safety shunt from an electric cap until you're actually ready to wire it into the circuit. If you remove the shunt to test the cap, replace it when you're through. If the cap has no shunt, keep the bare ends of the leg wires twisted together.

32. Don't use any firing device unless you're thoroughly familiar with its operation, and have studied all the safety instructions that go with it.

33. If you have to remove a firing device after it's been attached to a charge, don't expose the blasting cap, or percussion cap primer, or initiator, to any chance of impact.

34. When you set the delay time on a firing device, allow yourself a margin of safety. Don't remove the safety pin until you're ready to start the delay period. And after you've started the delay period, don't try to stop the firing device or reset the time delay.

35. Some devices eject the firing pin with a lot of force. When you're testing a firing device, even without a cap, don't point it toward any part of your body.

36. If you have a misfire with a clockwork device, handle it with extreme care until you've removed it from the charge. The clockwork may have stopped near the end of the delay period; a slight jar might start it up again.

37. A detonating cord initiator contains initiating compound; handle it as carefully as you would a blasting cap.

38. After you screw a Mk 2 initiator onto a coupling base, don't leave the percussion cap end of the coupling base unprotected. A blow on the percussion cap primer can detonate the whole assembly.

39. Don't let dirt get into the head of a detonating cord initiator. Any friction on the detonator pellet of the initiator during assembly can cause detonation.

QUIZ

In each of the following, select the BEST answer.

1. The average burning rate of blasting fuse is about
   - a. 45 feet per second
   - b. 45 seconds per foot
   - c. 4 miles per second
   - d. 40 minutes per foot
2. Which of the following contains no explosive?
   - a. Priming adapter
   - b. Nonelectric blasting cap
   - c. Electric blasting cap
   - d. Primacord

3. The coupling base is used to hold the percussion cap in
    - a. a primacord initiator
    - b. a mechanical device
    - c. a nonelectric blasting cap
    - d. an electric blasting cap

4. RDX is an ingredient of
    - a. blasting gelatin
    - b. tetrytol
    - c. PETN
    - d. compositions C2 and C3

5. Which of the following functions on the shaped-charge principle?
    - a. Cable and chain cutter Mk 1 Mod 1
    - b. Bangalore torpedo M1
    - c. Demolition charge Mk 1 Mod 0
    - d. Demolition outfit Mk 135 Mod 0

6. The cap crimper M2 should NOT be used to
    - a. form a bead around a nonelectric cap
    - b. drive screws
    - c. cut time fuse
    - d. cut blasting cable

7. The source of current for a blasting galvanometer is
    - a. a blasting machine
    - b. an electric cap
    - c. a storage battery
    - d. a silver chloride cell

8. Suppose that you make a test of four samples of time fuse, and get the results below. On which of them should you base your calculations for determining how much fuse to use on the charge?
    - a. 80 seconds
    - b. 78 seconds
    - c. 75 seconds
    - d. 79 seconds

9. If you find moisture in a nonelectric blasting cap,
    - a. blow it out gently
    - b. discard it and use another
    - c. dry it by pushing blotting paper into it
    - d. use another cap along with it

10. When should the shunt on special electric caps be removed?
    - a. Before the cap is removed from its box
    - b. As soon as the cap is removed from its box
    - c. When the cap is to be wired into the circuit
    - d. Never

11. When wiring two or more electric blasting caps in series,
    - a. test each one with a dry cell
    - b. pull the leg wires firmly to ensure continuity

    c. be sure all the caps are the same brand
    d. scrape the lacquer off the shell to ensure a good ground

12. Use the "leapfrog" series circuit when
    a. the charges are laid out in a line
    b. the charges are arranged in a circular pattern
    c. a 10-cap blasting machine is used
    d. caps of varying resistance are used
13. To test the blasting galvanometer,
    a. wire it to the blasting machine
    b. connect it to a new electric blasting cap
    c. connect the galvanometer terminals together
    d. connect the galvanometer terminals to a dry cell
14. If, when testing a circuit, you find that the galvanometer needle fails to move, which of the following is NOT a possible cause?
    a. Broken wire
    b. Dead silver chloride cell
    c. Defective electric blasting cap
    d. Short-circuited blasting cable
15. What is the proper procedure to follow if you discover, after setting a Mk 12 firing device to explode a charge and pulling the pin, that you've set the device for an incorrect delay time?
    a. Push the pin back into place.
    b. Stay clear; there's nothing you can do.
    c. Wedge the dial to prevent operation of the clockwork.
    d. Smash the device with a hatchet.
16. When should sealing compound be applied to primacord?
    a. When the cord is to be used under water
    b. At all splices
    c. After you remove the fabric covering
    d. Never
17. Why must you leave a 6-inch free end at a primacord splice?
    a. To prevent the blast from cutting the cord without transmitting the detonation
    b. To allow slack and prevent cord breakage
    c. To keep the cord temporarily waterproof
    d. To maintain the splice even if the cord slips
18. Which of the following cannot be used directly to set off a detonating cord initiator?
    a. Time fuse
    b. Nonelectric cap
    c. Electric cap
    d. Mechanical firing device

CHAPTER 12

BATTERY ALIGNMENT

PURPOSE OF BATTERY ALIGNMENT

In an earlier chapter you studied typical gunfire control systems installed aboard modern warships. The intricate mechanisms that make up these systems work together to solve complex fire control problems and make our gunfire, in a literal sense, superhuman in its accuracy.

This accuracy depends not only on the functioning of the mechanisms as individual units, but also on their alignment—both internal and external, both among themselves and with the guns that they control.

Your part as a Gunner's Mate in the job of battery alignment is to assist the fire control division on your ship in aligning and checking the alignment of all gun batteries. On small ships, the Chief Gunner's Mate is often required to assist in supervising the battery alignment job. That is why you should be familiar with the general principles of aligning a battery, and the procedures for conducting battery alignment checks, even before you tackle the job itself.

Every ship has it own special battery alignment problems, as you have probably found out by now. If you have a good grip on the principles, you'll be ready for the special kinks that have to be straightened out aboard your ship. This chapter will help you learn the principles and some of the standard routines of battery alignment.

Broadly, the purpose of battery alignment is to adjust the guns of the battery so that the lines of sight of the directors and gunsights, and the bore axes of the guns, are all parallel when the dials are matched and no ballistic corrections, or horizontal or vertical parallax corrections, are introduced.

To accomplish this, you must align all elements of the system to certain reference points, lines, or planes. These references are established on the ship by the yard that installs the ordnance equipment when the ship is first built. The yard determines these alignment references for both train and elevation, and marks them with permanent indexes or bench marks. To check the alignment or to realign the battery, the Gunner's Mate or Fire Control Technician goes back to these permanent bench marks.

On ships with only one director the problem of alignment is relatively simple: all the guns are aligned so that the one director becomes the reference and the guns are aligned to it. But on ships with more than one director, you must have a COMMON reference to which ALL guns and directors are aligned. Then, no matter which director is used to sight on the target, all guns will be in proper alignment.

Battery alignment may be divided into two general phases. They are, first, the INTERNAL mechanical alignment of the various parts of each element; and, second, the alignment of the various elements with one another, or SYSTEM alignment.

INTERNAL ALIGNMENT

Ordinarily, the Gunner's Mate will not be much concerned with internal mechanical alignment of fire control units outside the gun mount proper.

Within the gun mount or turret, the main elements whose alignment is important are the trunnions, the roller path, the sights, and the indicator dials.

Trunnion alignment in all recent armament can be considered as fixed at the time of construction. It isn't designed to be adjusted, and there's nothing to be done about it except as part of a major repair job. Pretty much the same is true of the roller path; you would have to lift the whole rotating structure to eliminate warps or similar irregularities.

So this phase of internal alignment is pretty much fixed, too. (Roller path compensation, which we'll get into later in this chapter, is not a matter of INTERNAL alignment; it's part of SYSTEM alignment, which we'll take up very soon.)

As for the sights, there you not only can but must adjust for proper alignment. That process is called boresighting. And alignment of indicator dials showing mount position is the whole objective of the tramming process. You are already well acquainted with the details of both these operations, which are taken up in earlier courses in this series.

Methods for checking the internal alignment of other elements of the fire control system are described in OP 762, *Alignment of Ordnance Installations Aboard Ship.*

Lost Motion

We have not mentioned the effects of wear and lost motion as they affect internal alignment; these are to be taken care of in the course of routine repair and adjustment.

However, you will have to deal with the effects of lost motion in other phases of battery alignment. The best procedure is to work so that lost motion has no chance to introduce error.

If you always approach a setting from one direction, there is no opportunity for lost motion to affect it. For example, you should always, whether you are elevating or depressing the gun muzzle, approach the elevation you want by going from a high to a low value. If you're depressing the gun, that's easy. If you're elevating, you should deliberately overshoot, then depress the gun to the value you want. By the same token, if you accidentally overshoot when depressing the gun, elevate again ABOVE the value you want so that you can again approach it from above. Ditto when you're training the mount. Approach all train settings from the right (or left, if you prefer, just so long as it's consistent).

This technique should by no means be new to you, since it was taken up in earlier courses in this series in connection with boresighting. Just be sure that your crews apply it consistently in all operations of this kind in battery alignment.

SYSTEM ALIGNMENT

System alignment may be subdivided into two phases—ORIGINAL ALIGNMENT in drydock, and ALIGNMENT AFLOAT. In your work you will be mostly concerned with alignment afloat. But you should know something about alignment in drydock too, so let's give it a brief once-over.

ORIGINAL ALIGNMENT IN DRYDOCK

The original alignment of ordnance installations is made in drydock by the shipbuilder or fitting out yard. Battery realignment in drydock usually takes place about every two years thereafter.

Its two principal phases are alignment in train and alignment in elevation. In the following discussion it is assumed that all elements of the system already have been properly installed and are functioning properly, and that these elements are mechanically aligned within themselves.

Alignment in Train

The purpose of battery alignment in train is to adjust the battery so that when the dials are matched, and no ballistics or horizontal parallax are introduced, the lines of sight of directors and guns, and the axes of the bores of the guns, are all parallel in train at any angle of train.

When in drydock, the first step in preparation for battery alignment in train is to establish a CENTERLINE from which to measure horizontal angles. In most cases, because of the interference of the ship's structure, this line will take the form of an "off-set centerline" ashore, parallel to the real centerline of the ship. The centerline is established by use of surveyor's transits.

Next we must establish the center of rotation of each trainable element, so that a transit may be set up to measure the true angle of train of the element. After we have plotted the center of rotation, it must be checked when the element is trained to see whether or not it remains on center. When it's verified, the center of rotation is then permanently scribed or engraved so that it can be used in future checks. On enclosed mounts, you'll find the mark on top of the shield.

The first step in actual alignment in train is the establishment of ZERO TRAIN; that is, setting the train dials of each element so that when the dials read zero train, the line of sight or axis of bore of each element is parallel to the centerline of the ship and pointing forward. On the after elements the dials are set at 180°, with elements pointing aft and parallel to the centerline.

With zero train established and the dials set, permanent reference marks must be established. A BENCH MARK and angular reading for each director and a tram reading for each mount or turret are established. At any future time when it is necessary to verify dial accuracy, each element can be trained onto its reference and the dial readings checked.

Alignment in Elevation

After battery alignment in train comes alignment in elevation. The purpose of alignment in elevation is to adjust the battery so that at ANY angle of train, and at ANY angle of elevation, the lines of sight of directors, the lines of sight of gunsights, and the axes of the bores of guns, will all be elevated by exactly the same angle above a common REFERENCE PLANE. (Again, we assume no vertical parallax or ballistics correction, and that dials match.)

To obtain data for elevation alignment we use a GUNNER'S QUADRANT. (This instrument will be taken up later in the chapter.) The principal operation in elevation alignment in drydock is the procurement and interpretation of roller path data. Roller path data are actually a series of readings showing the inclination of a trainable element (usually a gun mount or director) at points all around the roller path, relative to some fixed plane. In drydock this is usually a horizontal plane established by a spirit level. (At sea this REFERENCE PLANE is usually the roller path plane of the battery director.) The relationship between any roller path and the horizontal is defined by the AMOUNT of tilt at the highest point of the path, and the BEARING of this point. These are determined by interpretation of the roller path inclination readings.

As you can see, it is assumed, in making roller path correction, that roller paths are true flat circles, even though they may be tilted. In practice, there may be some slight distortions of the roller path from true circularity and true flatness, because of wear or accident, but these can be corrected only by shimming or otherwise reshaping the roller path, or by replacement. Present types of compensators can correct only for amounts and directions of tilt, not for irregularities in roller path shape.

Choosing the Reference Plane

The purpose of battery alignment in elevation, as we have seen, is to make sure that each elevating element always maintains the same vertical angle with the reference plane as all the other elements do, however much they may all elevate or depress. But how do we determine what plane to choose?

The plane chosen is usually an actual plane on the ship; that is, it is the plane of the roller path of one of the elements of the battery. Ideally, the plane chosen must have the smallest possible inclination between it and the roller paths of the other elements of the battery. The choice of this plane will vary, depending upon the type of ship. On destroyers the roller path of the main-battery director is ordinarily used as the reference plane. On larger ships with more than one director, the roller path of any director or mount may be chosen as the reference.

It is not necessary to have only one reference plane for all batteries or guns of a ship. A different plane can be selected for each battery. But in ships where secondary battery (AA or dual-purpose) directors can control more than one battery, one standard reference plane for those batteries is desirable.

Elevation Bench Marks and Tram Marks

The next step in elevation alignment is to set the elevation dials on the director and to establish the elevation bench marks. This requires the use of a surveyor's transit, which may be set up ashore or on deck. The gun elevation dials are then set and the tram readings established.

Stable Element

After the reference plane of the battery has been established, the next step is to align the stable vertical or stable element, so that its plane is exactly parallel to the reference plane. This is necessary because stable element train must agree with DIRECTOR train. This does not usually coincide with relative bearing in the horizontal plane. Therefore the stable element's plane of rotation must be corrected to be parallel to the reference plane, so that director train will produce the correct train of the stable element gimbals. No roller path tilt corrector is provided for the stable element. It must be aligned by shimming.

Setting Roller Path Compensators

The final step is to make the proper setting on the roller path tilt compensators at each mount or turret. Compensators vary in construction, but they all have either two or three scales to be set. We shall take up the procedure for setting roller path compensators or correctors later in this chapter.

BATTERY ALIGNMENT AFLOAT

As we pointed out earlier, alignment in drydock must be followed by final alignment afloat, because of the flexibility of the ship's structure. Therefore, when putting to sea, alignment must be checked and corrections made. This BATTERY ALIGNMENT AFLOAT requires somewhat different procedures from those in original alignment in drydock.

Transmission Check

To begin with, the synchro transmission system must be checked to ensure that transmitters are sending out the correct electrical signal for a given mechanical input, and that the receivers are converting this electrical signal into a mechanical motion equal to that of the transmitter input.

The synchro transmission check requires three main operations. First, you energize all synchros and set them to electrical zero. (Details on the procedure for setting synchros on electrical zero appear in chapter 4.) Second, you set the dials to read zero while the synchros are still at zero. Third, after the entire synchro system has been zeroed in this way, you verify the accuracy of data transmission. To do this, the fire control switchboard is set up so that signals may be transmitted directly from the director to the guns—if possible, without going through the computer. The telephones are then manned at the stations being tested. Then the director is trained and elevated to selected positions, and the gun mount and director crews read their dials over the phone to the plotting room. The plotting room crew compares the received readings with the transmitted values. They should check exactly.

At the gun mount, the crew should check the behavior of their indicators. There should be no oscillation of receiver dials, and indications should be steady. Any discrepancies noted should be investigated and corrections made as necessary.

System Alignment in Train

There are two phases to battery alignment afloat in train:

1. When the director is trained to any bearing, the mount dial pointers are matched, the sight deflection is set on zero, and NO parallax or ballistic corrections are set in, then the director line of sight, the gunsight lines of sight, and the bore axes of all the guns in the battery, must ALL be parallel to the bearing of the director.

2. Under conditions similar to those of the preceding paragraph, but with proper parallax correction introduced, the director and gunsight lines of sight, and the bore axes, must all converge on any given target at any given range and elevation.

The first phase corresponds to the similar requirements described earlier in this chapter in connection with alignment in drydock. To satisfy the second phase, it is necessary to introduce parallax into the system. It's therefore wise to check the parallax system before beginning the actual alignment.

You won't have to worry about vertical parallax correction; that's transmitted as a component of gun order. But since HORIZONTAL parallax correction is made by a mechanism in each mount, it's your baby as well as the FT's. Parallax correction is important aboard modern ships because of the relatively great horizontal distances of gun mounts from directors.

All parallax correctors should be checked for:

1. DIRECTION of applied parallax correction.
2. AMOUNT of parallax correction at various bearings and ranges.

As you remember from earlier courses in this series, horizontal parallax correction in dual-purpose batteries is usually generated by the computer as a function of range and bearing, for a standard base length (horizontal distance from gun mount to director) of 100 yards. Because the actual base length is almost never 100 yards, a parallax corrector (CHANGE-GEAR assembly) at the mount translates the correction based on 100 yards into the proper proportionate correction based on the actual distance of the mount from the director. Thus, with the proper correction applied to all mounts in the battery, all their lines of sight and bore axes will converge on any target held by the director, provided all dials match and no ballistic corrections are introduced.

The procedure for verifying and adjusting parallax correction at the director or computer is beyond the scope of this course, though you can get some information on it from OP 762. Once the change-gear assembly is installed in an indicator-regulator, it needs no further adjustment except for repair, or if either the mount or director are relocated. The thing to beware of in such cases, or if a new indicator-regulator is installed, is a parallax correction which may be of proper amount but is in the wrong DIRECTION. This is most likely to be caused by incorrect assembly of the change-gears on the mount. Or the synchro leads to the mechanism may be reversed.

One way to check this is to have gun and director trained on a target abeam and to have gun order for decreasing range to a target abeam transmitted to the indicator-regulator while the mount is set for AUTOMATIC. If the parallax change-gears are working right, the effect of increasing parallax correction by reducing range will be to cause the line of sight of the mounts to converge. You can sight through a trainer's or pointer's telescope to verify this.

Don't depend on observing the train angle dial to show this movement; in most turrets and all mounts parallax correction does NOT change the train angle dial indication.

Once you have verified that the parallax system is functioning properly, the next step is to check the agreement of the indicating dials in the director and gun mounts when the battery is trained on a common target. In preparation for this, the fire control division checks the director's dials by sighting on the director's benchmark; the mount crew prepares for this step by tramming the mount.

Now the director and gun mounts can be trained on a common target, proper parallax correction (but no ballistics) fed into the mount, and the director and mount dials compared. If there have been no errors in tramming, they will agree. (But here is a warning: They can agree when trained on a nearby target, only if parallax correction is properly introduced. That's why it's so important to check that parallax correction BEFORE starting this train alignment process.)

As a dry-land operation, this operation would not be particularly difficult. But when underway, or riding at anchor, you must expect some apparent target movement. (When your ship is tied up at a pier, you will probably have little trouble of this kind.)

There are several methods that may be used for checking the alignment under these conditions.

1. All trainers keep zero-readers and follow-the-pointer dials matched with the signal from the director. Director trainer signals "mark" when on target. An observer at the gunsight telescope adjusts the sight deflection setting until the gun's line of sight is on target at the "mark" signal. The amount of correction indicated on the deflection dial is the error of the train dial setting; with the gun stationary the dial is then adjusted by this indicated amount.

2. If bearing rate is quite slow, it is possible to improve upon this procedure by letting the director train slightly ahead of the bearing of the target and then stop so that all guns can match accurately. The director pointer sounds off "mark" as he swings across the target, and other stations get on as before. This method may prove satisfactory for a check with the ship at anchor in a roadstead.

3. A method different in principle is for all stations to stay on continuously, while the train dial indications at each mount are read on the signal "mark". Differences in dial readings then give the measure of errors. (In this method, the deflection setting should be the same on all mounts, and should not be changed during the alignment process.)

4. A fourth, and very commonly used, method is to align the battery on a prominent star or planet, using boresight telescopes. You do the work at night, and you can use any celestial body for an aiming point. For best results, the ship should be moored to a pier or should be lying in a quiet anchorage. At the mount, the parallax corrector should (since heavenly bodies can be considered "infinitely" distant) be set on zero. And the computer, sight angle and sight deflection inputs should be set on zero too. Now, with the power drives in AUTOMATIC, the director gets on target and the director trainer reports "mark" on the phone. The gun crew sights on the target through the boresight telescope and adjusts the train response couplings as required to bring the telescope crosshairs on the target.

NOTE. When sighting on a heavenly body, make sure that the whole battery is aiming at the same one. It is often easy to mistake one star for another. So it's best to use the moon, keeping all vertical crosshairs tangent to the same side.

If this alignment process reveals any substantial error in the train dial of a gun mount that has just been carefully trammed, you should check carefully, at once, into the source of the error. Perhaps the dial clamp is slipping, or the gear train may have excessive lost motion, or the tram setting may be improperly recorded. But take appropriate action as soon as you can.

System Alignment in Elevation

The object of system alignment in elevation afloat (as in drydock) is to adjust the battery so that at any angle of train or elevation, the gun bore axes and the lines of sight of the directors and gunsights will all be elevated by exactly the same angle above a common reference plane—provided that no vertical parallax or ballistic corrections are introduced, and the dials are matched.

As you know, the principal cause of misalignment in elevation is that the roller paths of the director and the gun mounts are not parallel. To adjust the battery to the reference plane—which is often that of the director roller path—it is necessary first to determine exactly how much and in what directions each of the gun mount roller paths is tilted as compared with the reference plane. To get these data we use the HORIZON CHECK. Let's see how this is done.

Principles of the Horizon Check

The horizon check is performed by comparing the elevation angles shown on the dials of the director and those shown on the dials of the gun mount, when both are aimed at a series of points around the horizon. Let's see how these angle readings can show the relative tilts of the roller paths. (Assume roller path correctors are at zero.)

Let's begin by using the director roller path as the reference plane. When its line of sight is perfectly horizontal, its elevation dials will read 2000 minutes at any point in train. (For the moment, neglect pitch and roll and variations in the trim of the ship.)

Next, let's assume that the gun mount roller path has, with respect to the reference plane, an inclination of 10 minutes with its high point at 270° train. Now if the gun and director are trained to 270°, the director dials will read 2000 minutes. But when the gun dial elevation reads 2000 minutes, the gun will actually be elevated 10 minutes above true horizontal, since its dials read only its elevation above its OWN roller path. (Fig. 12–1.)

If the gun is depressed to true horizontal its elevation dial will read 2000 minus 10, or 1990 minutes. Conversely, at the low point, or 90° train, when its dial reads 2000 minutes, the gun is really depressed 10 minutes below true horizontal. When elevated to true horizontal, it will read 2000 plus 10 or 2010 minutes. The director, of course, still reads 2000

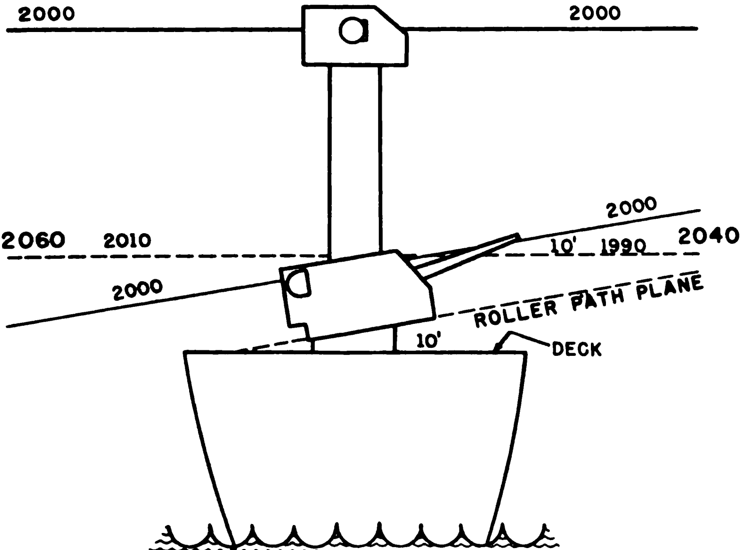


Figure 12–1.—Principle of the horizon check, with ship horizontal.

minutes. In both cases, the difference between gun and director readings is 10 minutes, plus in one case and minus in the other.

Now suppose we set in a sight angle of 50 minutes at the gun. At any position, the gun elevation will then be 50 minutes higher than before, with the sights on the same target. This will cause the gun elevation dials now to read 1990 plus 50, or 2040 minutes at the high point, and 2010 plus 50, or 2060 minutes at the low point. These readings are shown in the larger figures of figure 12–1. Now, comparing the gun and director readings:

	Bearing 90°	*Bearing 270°*
Gun	2060	2040
Director	2000	2000
Difference	60	40

We see that by introducing a sight angle we have caused the gun elevation reading to be higher than the director reading at both the high and low point of gun inclination (and of course at any point in between). But we also see that the difference is the LEAST at the HIGH point of the gun roller path. Thus, we can formulate the following procedure for making horizon checks:

1. Subtract the director reading from the gun elevation reading.
2. The least difference will then represent the high point of the gun roller path with respect to the director roller path.

To eliminate trouble in the algebraic sign of the difference found in step 2, you should, before beginning the horizon check, set in a sight angle on the mount approximately that for mean battle range. That way your results will all be positive in sign.

In the above we assumed that the ship remained on a true horizontal. But no error will be introduced if the ship heels over while the data are taken. In this case we would have the conditions shown in figure 12–2. The ship rolls 20°, or 1200 minutes. This depresses the line of sight of director and gun by the amount of roll, 1200 minutes. Then, to get back to true horizontal, each must be elevated by the same amount. This gives the readings shown on the figure; the difference is still the same, 3240 minus 3200, or 40 minutes.

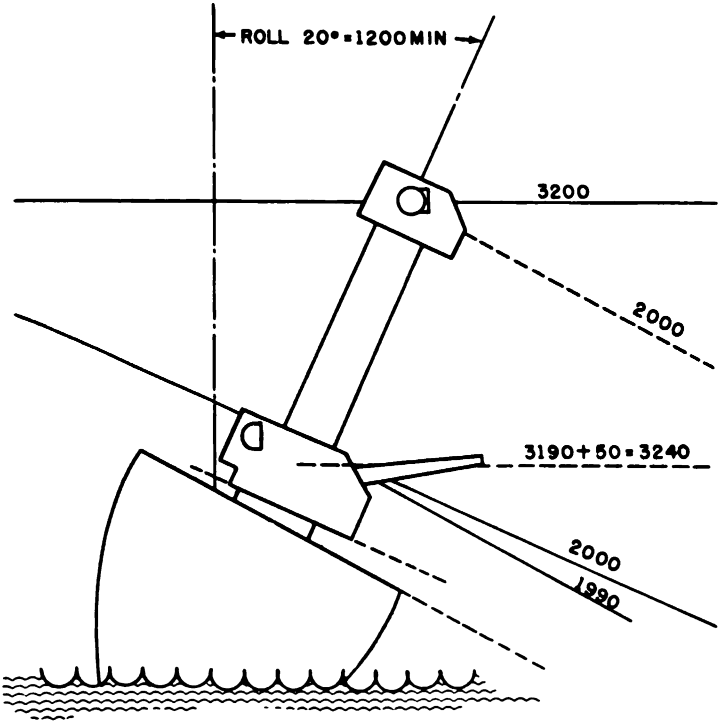


Figure 12–2.—Principle of the horizon check, with ship heeled 20°.

In the discussion above we have considered the director line of sight when truly horizontal. In practice we have no direct method of determining when the line of sight is truly horizontal (the stable vertical does not enter into this check), but must sight on the visible sea horizon. But figure 12–3 shows that in this case the two lines of sight will not be parallel—because of DIP.

A line to the horizon from any point above the water surface always dips slightly below the horizontal. The greater the height of the point, the greater the dip. You can calculate the approximate dip, in minutes of arc, by taking the square root of the height in feet. For example, if the gun trunnions are 16 feet above the waterline, dip at the gun is 4 minutes. And if the director telescope is 64 feet up, its dip is 8 minutes. You can see that the angle between the two lines of sight is equal to the difference in their dips, in this case, 4 minutes—provided there are no dial or roller path errors. Any other difference indicates an error. (To determine the EXACT dip, the calculation must be somewhat more refined. See OGS 12, TraPac 101, or Bowditch's *American Practical Navigator*. For horizon check purposes, however, the approximations given here will serve.)

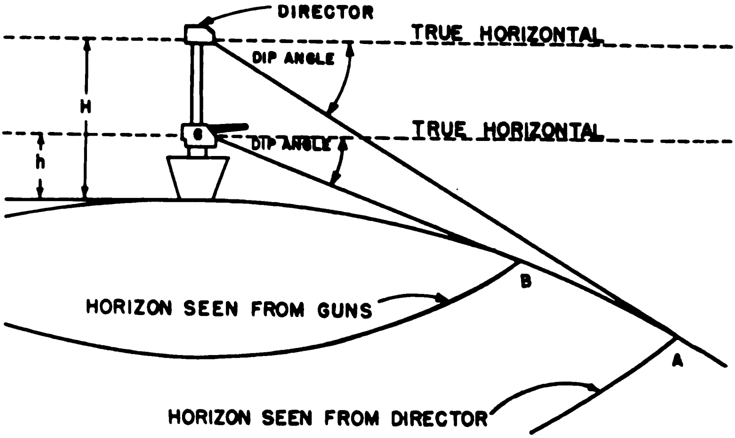


Figure 12-3.—Horizon dip at director and gun mount.

Imagine a gun and a director lined up on the horizon on the same bearing. The director pointer holds his telescope fixed at a setting near 2000 minutes and reads his elevation dials. (He could, of course, set his dials exactly at 2000 minutes, but it is often easier to read dials with greater accuracy than it is to set them, so this is the better way.)

As the director line of sight rolls across the horizon, the pointer calls "mark."

The gun pointer adjusts his handwheels until his line of sight crosses the horizon at the same instant that he hears "mark" from the director. He reads the gun elevation indicator dials. The difference between the director reading and the gun reading is the net result of three quantities:

DIP—a known quantity.
DIAL ERROR, if any—an unknown quantity.
ROLLER PATH ERROR—also unknown.

It's easy to separate the two unknown quantities. Dial error will be the same on all bearings. But roller path error will be positive on one bearing, negative on the opposite bearing, and will vary in between as the cosine of the bearing. The largest negative error will occur at the bearing of the roller path high point, since here you have to depress the gun.

In the above discussion, we have neglected the roller path compensation that is already introduced in the gun mount. The method of adding compensation is taken up later in the chapter.

Procedure for Horizon Check

The horizon check should be performed on a day when the ship has but little roll, and the horizon is clearly defined. The transmission check should be completed, the director checked on the bench mark, and the guns trammed. The fire control switchboard should be set up for normal operation. Sight angle and sight deflection inputs to the computer should be set to zero. Level and cross level should be set and locked at zero. Set the sight angle at 2000 minutes (or record the setting if one is to be introduced). If the check is to be performed with the boresight telescope, install and align the telescope. (In this case the sight angle and sight deflection settings will be immaterial.) However, if the gun has been carefully boresighted, it is usually sufficient (and always more convenient) to use the sights.

Man the telephones between director and gun, and train the director to a given bearing (within the train limits of the mount being checked). Set in a director elevation (actually depression) which will carry the director line of sight across the horizon as the ship rolls. Then train the gun to the same bearing as the director and match pointers in train.

To get the data, the director is trained to bearing 000°, then 010°, 020°, and so on around the circle. (Or the director may be trained in 15° increments.) At the same time the guns are trained on the same bearings. At each bearing, the director pointer sets his telescope near the 2000 minute mark, reads and records his dial settings, and then calls "mark" as his crosshairs cross the horizon. The gun pointers adjust their handwheels to bring their telescope crosshairs, or the boresight telescope crosshairs, on the horizon at the call of "mark." The gun elevation dials are then read and recorded.

Figure 12–4 shows a table of readings at a given gun mount typical of what might result from a horizon check. The first column shows bearings, the second gives dial readings at the director; the third, dial readings at the gun; and th fourth, the difference between the third and second.

The figures in the fourth column, then, are the sum o DIP DIFFERENCE, DIAL ERROR, and ROLLER PATH ERROR The first two quantities are the same on all bearings. Th third varies as the cosine of the bearing. Therefore, if yo plot the column 4 figures, with bearing along the horizonta axis and error along the vertical (as in fig. 12–5), the point will fall on a cosine curve, but the curve will be raised bodil above the zero line by an amount equal to the two constan quantities.

Analysis of Horizon Check Results—Sine Method

Now your problem is to find, from the data, where the roller path high point is and what the amount of the inclination is at the high point.

There are three graphical methods available for this analysis—the sine curve method, the 60° radial method, and the 180° radial method. Let us analyze the data in figure 12–4 by each of the three.

ROLLER PATH DATA

(1) Bearing	(2) A Director 1	(3) B Mount 51	(4) B–A Difference
000	2001	2009	8
010	2001	2010	9
020	2002	2012	10
030	1997	2008	11
040	1996	2008	12
050	1996	2008	12
060	1996	2008	12
070	2000	2012	12
080	2005	2017	12
090	2005	2016	11
100	2005	2015	10
110	2003	2012	9
120	2003	2011	8
130	1997	2004	7
140	1997	2002	5
150	----	----	--
160	----	----	--
170	----	----	--
180	----	----	--
190	----	----	--
200	----	----	--
210	----	----	--
220	2001	1998	−3
230	2001	1998	−3
240	2001	1997	−4
250	2005	2001	−4
260	2005	2002	−3
270	2005	2002	−3
280	2005	2004	−1
290	2002	2002	0
300	2002	2003	1
310	2002	2004	2
320	2002	2006	4
330	2002	2006	4
340	2000	2006	6
350	2000	2007	7

Figure 12–4.—Readings taken from horizon check.

If you skim down column 4 (fig. 12–4), you will see that the differences are largest near 060° bearing. This means you had to elevate a relatively long way to get the line of sight parallel at this point to the roller path. The low point is evidently in the neighborhood of 060°, but you can't tell, off-hand, exactly where it is or how low it is. So you get some graph paper and draw a smooth curve through the plotted points. (Fig. 12–5.)

This curve will be a cosine curve, since the correction is proportional to the cosine of the train angle. If you have a good eye, you may be able to draw the curve free hand. If not, charts showing curves of many different heights are available. (One set is in OP 762, another is in OGS 12 or TraPac 101.)

These curves will be labeled "sine curves", but don't let that bother you—sine and cosine curves have the same shape. Using such a chart, you find the curve which best fits the plotted points. Notice that all the points won't fall on the line—the important thing is to pick the curve so that just as many points fall above the line as fall below. Some wild points may be a long way from the others. These obviously result from errors in reading. Disregard them.

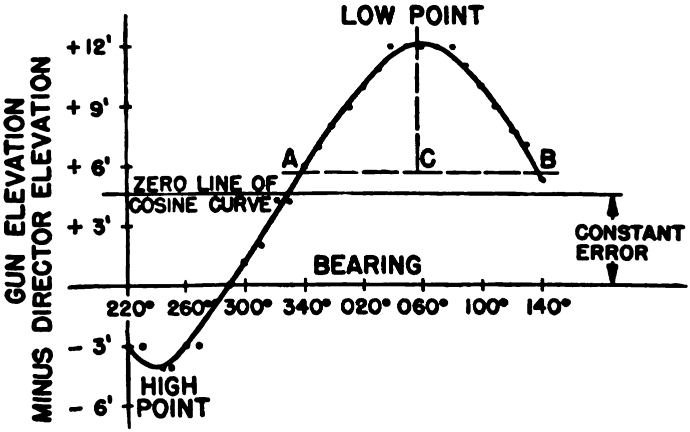


Figure 12–5.—Plotting roller path data—sine curve method.

Once you have found the right sine curve, it's no trick to find the high and low points. Remember that a peak on the chart means a low point on the roller path—because the lower the path is, the more you have to elevate the gun and the larger your reading.

To find the high or low point on the graph, simply draw any horizontal line, such as *AB* in figure 12–5, cutting the curve in two places. Find the point *C*, midway between *A* and *B*, and erect a perpendicular at *C*. Then, because a sine or cosine curve is symmetrical, the perpendicular will intersect the curve at its peak.

In this case, then, the low point lies on a bearing of about 059°. Therefore the bearing of the high point is 059°+180°, or 239°.

You still need the value of the inclination at the high (or low) point. You know that zero points of a sine or cosine curve lie 90° on either side of the peaks. Hence there is a zero point at 329°. The height of the curve at this bearing is about 4.5 minutes. The height at the low point is 12.5 minutes. Therefore the inclination—the difference between them—is 8 minutes.

Now you can check up on the constant error also. At bearing 329°, where the value of the cosine function is zero, the height of the plotted difference curve is 4.5 minutes. This is the constant error. But you have already computed the value of dip difference—4 minutes. Therefore the dial error is negligible. If you found a substantial dial error, it might be necessary to open a coupling in the response shaft from gun to indicator and reset the dial.

Horizon Check Analysis—180° Radial Method

The theory of the sine curve method of plotting just outlined is simple. But in practice it's not too easy to fit a sine curve accurately to the observed data. This is especially true if the mount has a limited arc of train. But by using a trigonometric trick it is possible to plot the data so that it fits a CIRCLE instead of a sine curve. Since a circle can be drawn with a compass, this method is much easier to work and gives more accurate results—even though the theory is a little more complicated. This method does not give any value for the constant error, but, most often, all you want are the roller path data anyway.

Figure 12–6 shows you how to set up the data for plotting by the 180° method. In the first column, headed LOW bearing, list the bearings of all the observations you have taken which fall between 000° and 180°. Opposite these bearings, in the second column, list the gun-director differences given in column 4 of figure 12–4. In the high bearing column, list the bearings of observations on bearings between 180° and 360°—placing them so that entries in the low bearing and high bearing columns are exactly 180° apart. Tabulate the

ROLLER PATH PLOTTING DATA
(180° Method)

(1) Low Bearing (000°–180°)	(2) Gun-Dir (A) (roller path + constant error)	(3) High Bearing (180°–360°)	(4) Gun-Dir (B) (roller path + constant error)	(5) B–A (twice roller path error)
000	8	---	---	---
010	9	---	---	---
020	10	---	---	---
030	11	---	---	---
040	12	220	−3	−15
050	12	230	−3	−15
060	12	240	−4	−16
070	12	250	−4	−16
080	12	260	−3	−15
090	11	270	−3	−14
100	10	280	−1	−11
110	9	290	0	− 9
120	8	300	1	− 7
130	7	310	2	− 5
140	5	320	4	− 1
---	--	330	4	----
---	--	340	6	----
---	--	350	7	----

Figure 12–6.—How to set up data for 180° radial plot.

corresponding gun-director differences in column 4. In the last column, headed B–A, enter the HIGH bearing difference MINUS the LOW bearing difference. BE SURE TO TAKE ACCOUNT OF THE ALGEBRAIC SIGN.

Now you are ready to plot the points. You can do the plotting on special POLAR COORDINATE paper provided for the purpose, or on ordinary maneuvering board paper available from the navigation department. Or, using a protractor, you can plot on plain paper. Figure 12–7 shows the data of figure 12–6 plotted by the 180° method.

Any point on a polar coordinate graph is located by its DISTANCE from the center or origin (zero point), and by its ANGULAR POSITION—in this case, the bearing. To plot each entry in column 5 of figure 12–6, you first locate the circle on which it must lie. Then you mark the point at which that circle intersects the appropriate bearing. You read the bearing for each entry from column 1 (low bearing) if it is POSITIVE or from column 3 (high bearing) if it is NEGATIVE. Thus, in figure 12–7, the first point in column 5 (−15) is plotted on bearing 220° because it is negative.

Now locate the circle which best fits the plotted points. You do this by trial and error with a compass. Be sure that as many points lie inside the circle as outside, and be sure that the circle passes through the center point (0) of the diagram. Draw the diameter of the circle through 0. The length of the diameter represents TWICE the inclination. So the length of the radius will equal the inclination (in minutes) and the bearing of the radius will be that of the high point. Notice in figure 12–7 that, again, the inclination is 8 minutes and the high point bearing is 239°.

This method appears to have a lot of arbitrary rules about which number to subtract from which, when to use high bearings, when to use low. But it's not as bad as it looks. You can subtract gun readings from director readings, or subtract column B from column A, or plot negative errors on the low bearings. Any of these methods will give you the right answer. But the bearing you end up with may be a low point instead of a high point. You can always tell which

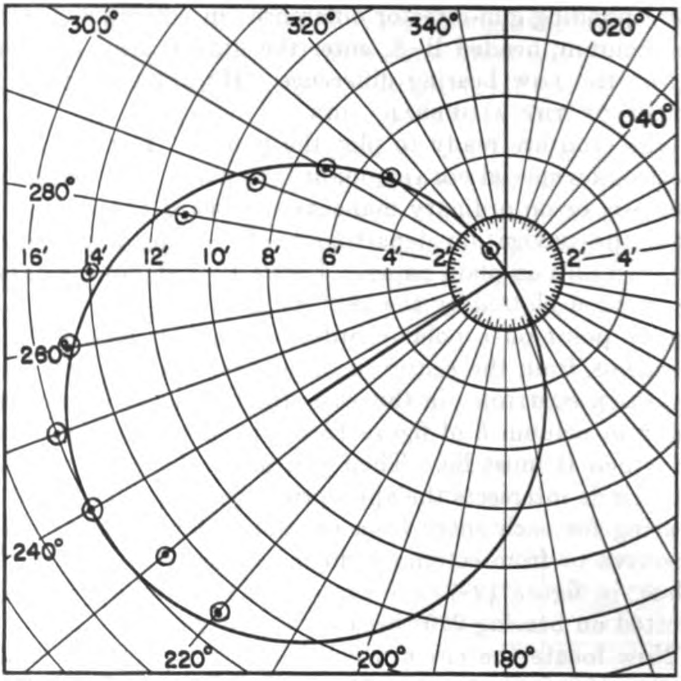


Figure 12-7.—Plotting the roller path data—180° radial method.

you have by going back to the original readings at the mount. Just remember that on a high point, you have to depress the gun, and therefore the dial readings are low.

Horizon Check Analysis—60° Radial Method

The 180° method is fast and accurate if you have enough points which are 180° apart. But if the gun has a very limited angle of train, there may be few such points—or even none at all. In such cases you can use the 60° method.

For the 60° method, you set up your data in tabular form much as you do in the 180° method. Figure 12-8 shows the data used in illustrating the 180° method, tabulated here for the 60° method. Note that we have now assumed that the gun mount in question is capable of only 140° train, so data only for bearings 000 to 140 are included.

ROLLER PATH PLOTTING DATA

(60° Method)

(1) LOW BEARING	(2) GUN – DIR (A) (roller path plus constant error)	(3) HIGH BEARING	(4) GUN – DIR (B) (roller path plus constant error)	(5) B – A (roller path error on low bearing minus 60°)
000	8	060	12	4
010	9	070	12	3
020	10	080	12	2
030	11	090	11	0
040	12	100	10	–2
030	12	110	9	–3
060	12	120	8	–4
070	12	130	7	–5
080	12	140	5	–7

Figure 12–8.—How to set up data for 60° radial plot.

The data are set up in five columns, with column 1 showing bearings from 000 to 080, and column 2 showing differences between gun mount and director readings (minus dip, but including "constant error" due to dial misalignment, which does not concern us right here) at each bearing. Column 3 lists bearings 60° higher than those in column 1, from 060 to 140, with entries in column 4 for those bearings. Note that here, because three bearings (060, 070, and 080) are repeated in column 4, so are their entries. Column 5 shows the differences (including plus or minus sign) between entries in columns 2 and 4.

Once you have made up your table of entries properly, you are ready to plot column 5 values on polar coordinate paper. (Fig. 12–9.) This is a little tricky, so watch it carefully. Plot POSITIVE values on LOW (column 1) bearings. Plot NEGATIVE values on the coordinate paper 180° away from the LOW (column 3) bearing. For example, you plot the —2 entry (encircled in column 5 of figure 12–8) on the 220° line of the coordinate paper.

Then draw a circle through the plotted points. The amount of inclination of the roller path in minutes is represented by the DIAMETER (not the radius) of the circle. And the bearing of the high point is 60° LESS than the bearing of the diameter through point 0.

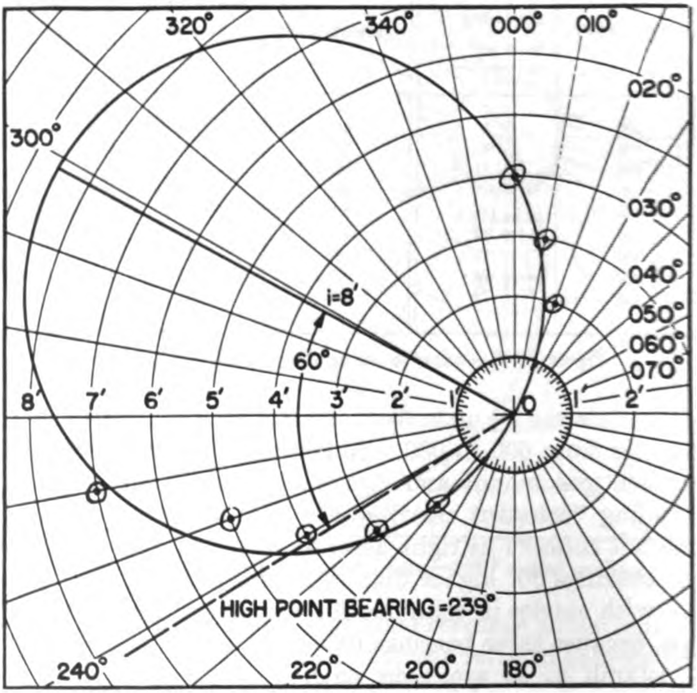


Figure 12-9.—Plot of roller path data—60° radial method.

You are not likely to go far wrong on any of the three methods of plotting roller path data—except for one thing. Be sure you don't get a high point confused with a low point. You can always tell whether you have located a high or low point by going back to the original readings you made at the gun. Remember that, on the high side of the roller path, you have to depress the gun below its zero to put the telescope on the horizon. Therefore, readings near a high point will be small; near a low point they will be large.

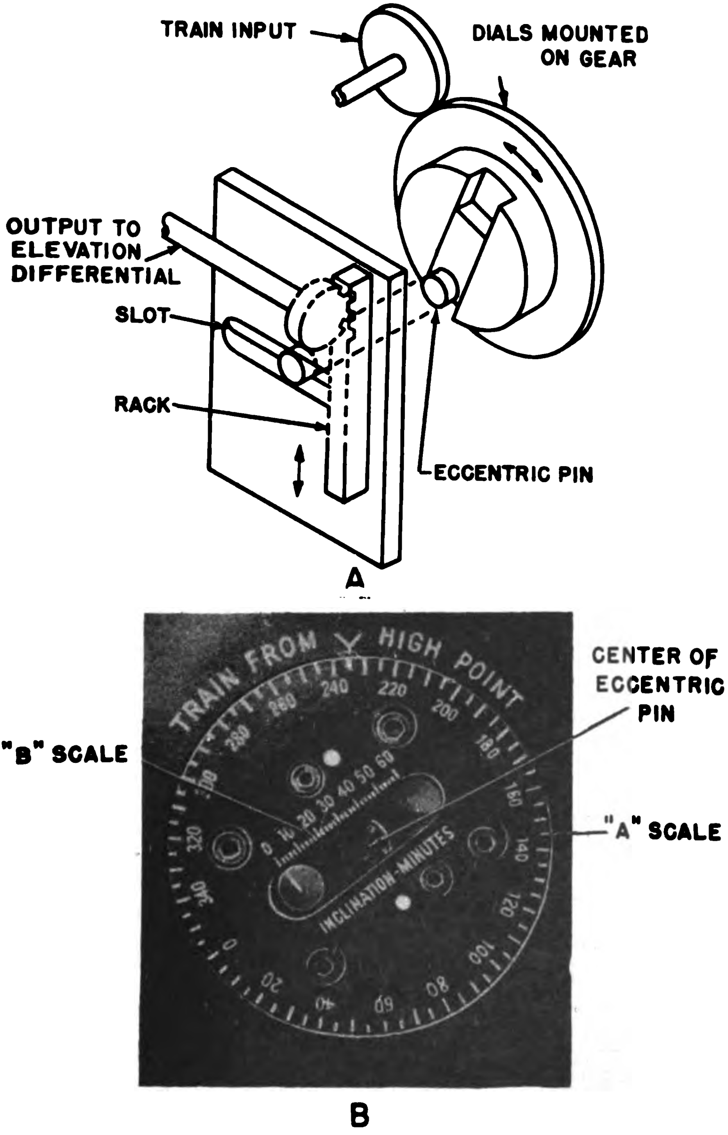


Figure 12–10.—Roller path compensator (5-inch twin mount). A. Schematic. B. Dials.

Roller Path Compensator

Now we know the amount and direction of tilt of the gun mount roller path with respect to the reference plane. Though it may be theoretically possible to remove the gun mount from the roller path and align the roller path by shimming it and shaving it (as, in fact, is sometimes done with director roller paths), the same result is much more economically attained, as you know, by using a ROLLER PATH COMPENSATOR. The compensator merely increases gun elevation at certain angles of train where the roller path is low, and reduces it at others where the roller path is high. Once set, the compensator is completely automatic. A common type (as used on 5-inch twin mounts) is shown in figure 12–10, *A*. Here is how it works:

Train angle is transmitted to a gear in the roller path compensator. The gear carries a train dial and an eccentric pin whose eccentricity can be adjusted to be equal to the maximum inclination. This pin operates in a slot in a rack. As the mount moves in train, the eccentric pin moves the rack up or down. A pinion transmits rack movement to a differential, in which the movement is added to or subtracted from gun order, depending on the setting of the compensator mechanism and the angle of train.

Figure 12–10, *B* shows the dial face of the compensator. There are two scales, "A" and "B." Scale "A" is used to determine the bearing of the high point of the roller path; the setting of the index on scale "B" determines the amount of maximum tilt. As shown in the figure, the eccentric pin is set at zero, right in the center of the dial gear, so that it cannot move the rack at all. The farther off center it is, the greater the movement of the rack, and the greater the compensator's output into the elevation differential.

Scale "A" is graduated from 0° to 360° and is set so that the reading against a fixed index represents train angle from the high point. The eccentric pin can be set at any eccentricity from 0 to 60 minutes on scale "B."

Roller path inclination is added to actual gun elevation in the same way parallax correction is added to train, and does NOT show in the reading of the elevation dials.

To set the roller path compensator:

1. Train the mount to the roller path high point and set scale "A" to read zero against its fixed index. If it is impossible to train the mount to the high point, train the mount to the roller path low point and set the roller path compensator to read 180° against its fixed index. Or, if some other bearing must be used, the reading of the roller path compensator dial against its fixed index must represent the number of degrees that the mount is trained RIGHT from the roller path high point.
2. Set the amount of compensation by adjusting the index on scale "B" to the desired tilt in minutes.

The roller path compensator illustrated in this section is the newer type found, among other places, in 5"/38 twin mounts (Ford indicator-regulators), 5"/54 mounts, and some turret receiver-regulator units. An older "3-scale" type is used in 5"/38 single mounts and in the indicators for certain turret receiver-regulators. The operating principles of this older type resemble those of the newer, but the nomenclature and setting of the scales are somewhat different. For further information on a typical model of the 3-scale type, see OP 1066.

Calculation of Compensator Setting

In the preceding section we have assumed, in showing how to set the roller path compensator, that no roller path correction has already been made in the gun mount. This is the usual situation in drydock, when the compensator has been zeroed before roller path tilt is measured with the gunner's quadrant.

However, the horizon check is normally performed with some setting ALREADY on the roller path compensator. Therefore, the tilt found by the check is in reality not the total inclination. The error we have just found must be added to the setting which already exists in order to determine the TOTAL inclination for which the compensator must be set.

This is best accomplished graphically, as shown in figure 12–11. Let's assume the compensator was originally set for 8 minutes inclination at 150°. How do we add the new compensation for the error we discovered? (It was, you recollect, 8 minutes at 059°.)

To begin with, we can NOT add these expressions arithmetically, because they represent not merely QUANTITIES but DIRECTIONS also. To say that 8 minutes plus 8 minutes equals 16 minutes and that 150° plus 059° equals 209°, and that consequently the combined error to be compensated is 16 minutes at 209°—all this is an absurdity. To make this addition we must use a method that will show direction as well as quantity. We use VECTORS.

If you have studied basic mathematics (NavPers 10069/70–A are good textbooks on it) you are already acquainted with vectors. A vector is nothing but a straight line whose direction represents the direction of what it symbolizes, and whose length is proportional to the magnitude of what it symbolizes. With a protractor and a ruler, we can represent the existing setting of the roller path compensator as one line whose direction is the same as that of the compensator setting, and whose length is proportional to it. And we can represent the newly found error as another line, beginning from the same point as the first one, with direction and length corresponding to the new error. Arrowheads on the lines indicate the SENSE of the vectors represented. (Sense is the way you're headed on the vector; without the arrow you might be proceeding in either of two senses.) Here is the procedure in detail:

a. Draw line *OA* to represent zero train.
b. Plot the original setting of the compensator 8 minutes at 150°, as line *AC*. Do this by actually measuring off the angle clockwise from *OA* and laying off the amount of inclination on that line to a convenient scale.
c. Similarly plot the newly found inclination as *AB*.
d. Then draw *CD* parallel to *AB*, and *BD* parallel to *AC*. These intersect at point *D*, and make a PARALLELOGRAM.

e. Draw the line *AD* from the origin to *D*. THIS REPRESENTS THE TOTAL INCLINATION that we are seeking. Measure its bearing with a protractor. Measure its length, using the same scale as for the other lines in the diagram. You now have the amount of the inclination at that bearing. Your answer is that the bearing is 105° and the inclination at that bearing is 11.5 minutes 5 seconds.

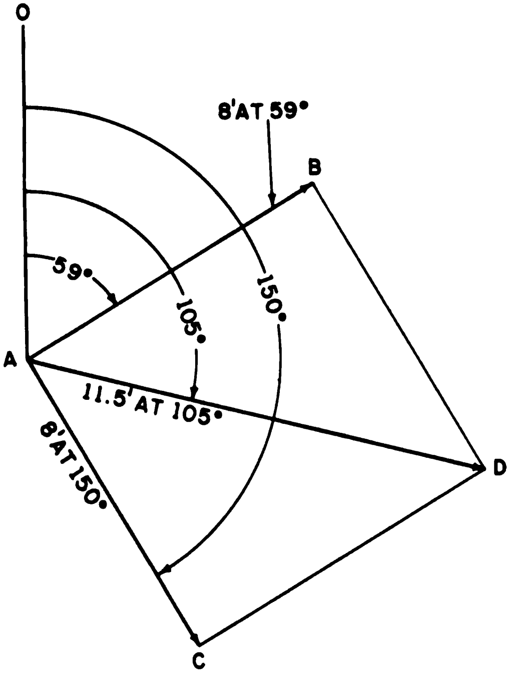


Figure 12-11.—Determining the compensator setting (graphical method).

These are the data which must be set into the compensator. By this time you may have noticed that, strictly speaking, we set the roller path ERROR into the compensator, not the correction. So don't go through any mathematical manipulations, like changing positive quantities to negative, to work out the correction for any measured error. Just set the

ERROR, as measured and calculated, into the compensator, and let the instrument itself do the rest. That's what it's designed for.

Checking the Gun Automatic Follow-Up System

After the battery has been aligned in elevation you should make a test of the automatic follow-up system of each gun mount.

This test is accomplished with the entire fire control system energized, and the switchboard set up for normal operation. The fire control division selects several targets at different train angles and at such ranges that the targets are visible from the guns, and trains out the director so that its line of sight is on the target. Then they obtain the range to the target, and transmit this range to the computer. At the computer, they make all the proper settings so that the computer will solve the problem for that target, will transmit gun train order and gun elevation order to the mount power drives, and transmit sight angle and sight deflection to the sight setting mechanisms at the gun mounts.

Your part in this procedure is to place the guns in full automatic and match the pointers at the sight setting mechanism. Observe the target through the gunsights. If the entire system is functioning properly, and if the guns are properly boresighted and aligned, the gun sights will be on the target in elevation. There is one precaution, however: with the 5″/38 battery, where vertical parallax is included in the computation of superelevation (which in turn is included in sight angle) the sight will be slightly BELOW the target in automatic control.

(You can get a pretty thorough explanation of this apparent discrepancy from any Fire Control Technician who's on the ball. We have space here for only a rather simplified one, just to satisfy your curiosity: For an air target at any range and any reasonably great height, it's obvious that the higher your location, the less you'll have to elevate your line of sight. So the gunsight line of sight must be elevated more than that of the director. Vertical parallax correction from the computer takes care of this extra elevation, and introduces it both into gun order to the indicator-regulator, and into sight angle to the sight setter's indicator. Thus, in automatic, the whole gun mount, with the sights mounted on it, is already positioned by the power drive to make the correction, when the sight setter matches pointers with his synchros. But his sight angle synchro ALSO receives this correction. The sight setter therefore over-corrects, and depresses the sights a little too much. Result: When the gun is "on target" in automatic, the target's always below the crosshairs. In local control, of course, only the corrections in the sight setter's synchros are transmitted, so this slight error does not exist, while in automatic it doesn't much matter.)

If the sights are not on the target, they may be brought on by the sight angle knob. Then the difference between the two indexes of the sight angle follow-the-pointer dial represents the error existing in the system.

Repeat this procedure for other targets at different angles of train and obtain the error at each train angle.

If it is quite certain that the entire system is functioning properly, and the battery has been properly aligned, this error is most probably in the automatic follow-up system and the mechanical dial system. To arrive at this conclusion it must be assumed that:

1. The stable element is functioning properly.
2. The entire transmission system is functioning properly.
3. The computer is solving the problem correctly and thereby generating the correct gun order and sight setting. This implies also that the range to the target was measured correctly.
4. There is no lag in the follow-up system at the gun.
5. The sight angle mechanism at the gun, including the receiver, is functioning properly.

All these assumptions can be made safely only immediately after aligning the battery and checking each unit of the system. Therefore this test should be performed immediately after the alignment. It may be used as a check thereafter, but if an error is discovered, the other elements of the system must be checked before it can be assumed that the error is in the gun response system.

If an error of gun response is indicated it should be eliminated by adjusting the gun response to the follow-up system. A micro-coupling is usually provided for this purpose.

DIRECTOR CHECK

The purpose of the DIRECTOR CHECK is to verify battery alignment; in other words, to determine whether the line of sight of every gunsight is in exact alignment with the line of sight of the director.

This check should be made after repair work on any part of the control system, and whenever there is any suspicion that the battery is out of alignment with the director.

In principle the director check consists of bringing the director onto some selected target and bringing the guns and the gunsights, or a boresight telescope mounted in the gun bore, to the same target using HAND, LOCAL, or MANUAL control. Then by comparing the readings of the dials in the mount with those in the director, you can tell how accurately the guns are aligned with the director. In actual practice this process is complicated by the movement of the ship.

Director checks are made in both train and elevation. You will always work with the fire control division in making director checks.

Director Check in Train

The director check in train is made following the same procedure as outlined for aligning the system, except that errors are recorded, and no corrections are made until the check is completed and the errors are analyzed. It is best to have the parallax correction made by the parallax correctors, and the guns elevated to battle elevation. Check the alignment of the guns and director successively on equally spaced bearings (such as every 15°) throughout the entire arc of train, recording error data for each bearing. To make the observations as systematic as possible, make all checks throughout the arc from the SAME direction, to ensure that lost motion enters each observation in the same manner. The amount of lost motion can then be determined by a partial check in the other direction.

Director Check in Elevation

This check is similar to the horizon check procedure already described, with all data to be recorded and the errors to be analyzed. Before making such checks, the director line of sight should be put on the bench mark and the indicating system checked against the bench mark reading.

Simple Elevation Check

It's a good idea to perform a simple test in elevation at frequent intervals while at sea. This is done exactly as in the horizon check, except that each gun is checked at only one point on the horizon. The difference between gun and director readings, after correction for sight angle, should equal the dip correction of the gun. If it does not, an error of some sort is present and must be investigated. Before undertaking a complete director check as a result of this test, check to see that the transmission system is functioning correctly and that the roller path tilt compensator is at its correct setting for both bearing and inclination.

GUNNER'S QUADRANT

As you remember from earlier in this chapter, one of the instruments essential in battery alignment ashore is the GUNNER'S QUADRANT. True, you won't be as often concerned with alignment ashore as you will be with alignment afloat, but alignment ashore must be treated as ORIGINAL alignment. Even though alignment done in drydock must be corrected for distortions in the ship's structure, it's fundamental. And you are expected, as Chief Gunner's Mate, to know how to use the gunner's quadrant.

The gunner's quadrant is an instrument for measuring the angle of inclination of a surface from the true horizontal. (The true horizontal is defined as plane tangent to the earth's surface at the point of measurement.) In other words, it

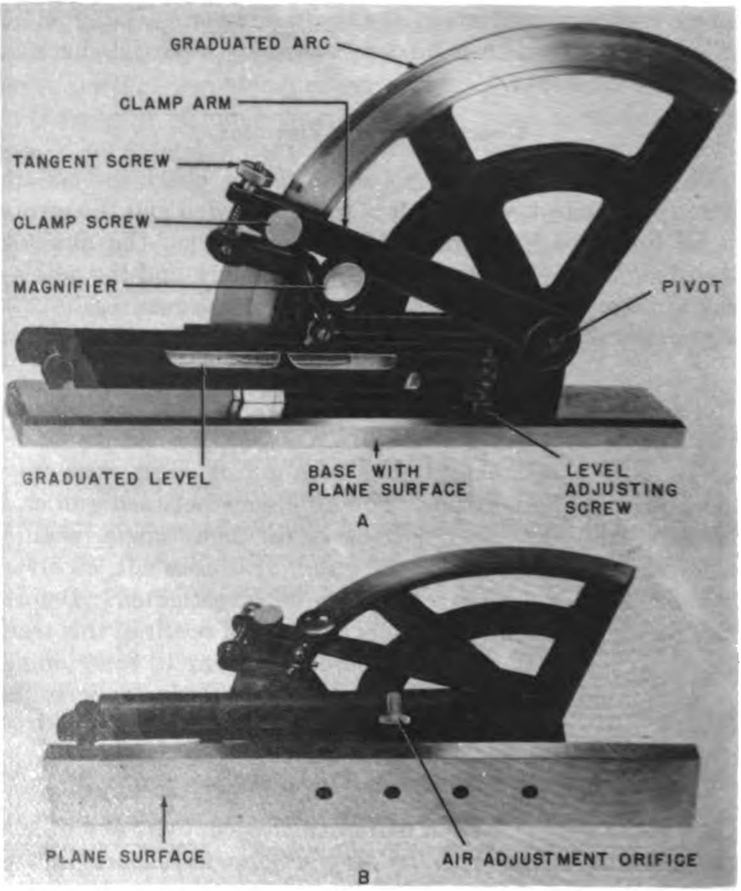


Figure 12–12.—Gunner's quadrant Mk 3 Mod 1 (vernier scale type).

measures "how much" a surface is inclined from the true level. You can think of the instrument as a glorified and more precise carpenter's level with an arc for measuring the angle of inclination.

The first gunner's quadrants were devised back in the days of muzzle loading to provide a quick way of measuring the elevation of the gun before firing. They are still used for that purpose today on some forms of rocket launchers and mortars. But the chief use you will make of them will be aboard ship, when drydocked, to measure inclination of the roller path of the various gun mounts from the reference plane.

Note that here, unlike the procedure in horizon checks performed afloat, you ZERO all compensators before measuring the inclination with the gunner's quadrant.

The gunner's quadrant Mk 3 Mod 1 (fig. 12–12) consists of a base, the bottom of which is ground to an accurate plane surface, an arc mounted perpendicularly on the base, an arm containing a spirit level, and a clamp arm.

The level arm and clamp arm are pivoted to the arc. The clamp arm serves to secure the level at any particular position on the arc by means of the clamp screw. The clamp arm is connected to the level arm by a tangent screw for making fine adjustments between the clamp and the level. The level in the level arm is a slightly curved graduated glass tube filled with colored alcohol and containing an air bubble. The upper surface of the glass tube is graduated so that the bubble can be accurately centered. The level arm also carries the vernier scale, which slides along the arc, and a magnifier glass.

The glass vial containing the spirit level is enclosed in a metal tube with only five inches of its upper surface exposed. The glass is graduated in units of ten seconds (10″) of arc.

The main scale is 100° long, and its smallest graduation (fig. 12–13) is 15 minutes (15′) of arc. (In some mods, the degrees are divided into six parts of 10 minutes of arc each.) Each main division of the vernier scale represents 5 minutes, and the next smaller graduation represents minutes. The smallest graduations represent 20 seconds of arc each.

To use the gunner's quadrant, place it carefully on a flat surface parallel to the axis of the gun bore or other object to be measured, and with the quadrant pivot toward the center of rotation. Bring the level bubble approximately to the center of the bubble tube by adjusting the clamp arm and level arm positions on the arc. Tighten the clamp screw to hold the arms in position. Then turn the tangent screw slowly in the proper direction to bring the bubble exactly into

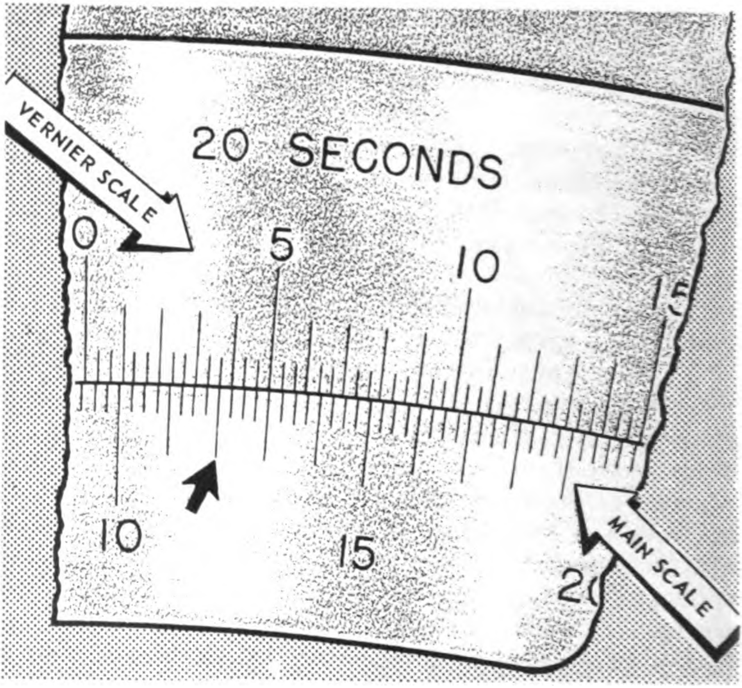


Figure 12–13.—Vernier scale of the gunner's quadrant.

the center of the tube. You can then read the measured angle from the arc and vernier scale.

In reading the scale, count along graduations on the arc scale until you come to the zero on the vernier. This will give you a ROUGH reading in degrees and minutes. To get the fine reading, count from the zero on the vernier scale until you come to the division on the vernier scale that lines up exactly with a division on the arc scale. This will give you the FINE reading. Add the coarse and fine readings together to get the total angle of inclination.

You should already be familiar with how to read vernier scales. If you're rusty on it, see the Navy training course for GM 3 (NavPers 10181). One of the questions at the end of this chapter requires you to read the indication in figure 12–13.

Often the difference between consecutive readings of a gunner's quadrant will be so small that it is not necessary to center the bubble for each reading. Instead, the second reading can be read directly in terms of the displacement of the bubble from its center position.

Assume that we are taking roller path data for a gun mount. The quadrant reads 0° 18 minutes 20 seconds when the gun mount is trained to 180°. Then we train the mount to 190° and read the quadrant again. We find that the bubble has moved two graduations—20 seconds—away from the center. If the bubble moved away from the pivot point, the 20 seconds should be subtracted from the first reading. This makes the second reading 0° 18 minutes 0 seconds. If the bubble moved TOWARD the pivot point, however, the second reading would have been 18 minutes 40 seconds.

Referring again to figure 12–12, *A*, notice that the length of the bubble corresponds exactly to the distance between the two graduations subtended by the small black dots. This is the correct length for the bubble. As the temperature changes, however, the air in the bubble expands and contracts with the contraction and expansion of the liquid. Thus the length of the bubble varies inversely with the temperature.

You can adjust the length of the bubble by adding or subtracting air. A portion of the glass vial (fig. 12–12, *B*) is partitioned off by a glass disc with a small orifice milled in its bottom edge. Extra air is contained in this compartment. If the bubble is too short, stand the quadrant on its base with the pivot down and bleed more air into the main chamber. If the bubble is too large, reverse the procedure.

Mk 7 Gunner's Quadrant (Drum Type)

The Mk 7 gunner's quadrant (fig. 12–14) has been designed for easy reading. The vernier scale has been replaced by a micrometer drum mounted on the shaft of the tangent screw. For coarse adjustments, the level arm can be moved to any position by disengaging the tangent screw from the teeth cut on the arc.

Always be careful in reengaging the tangent screw after

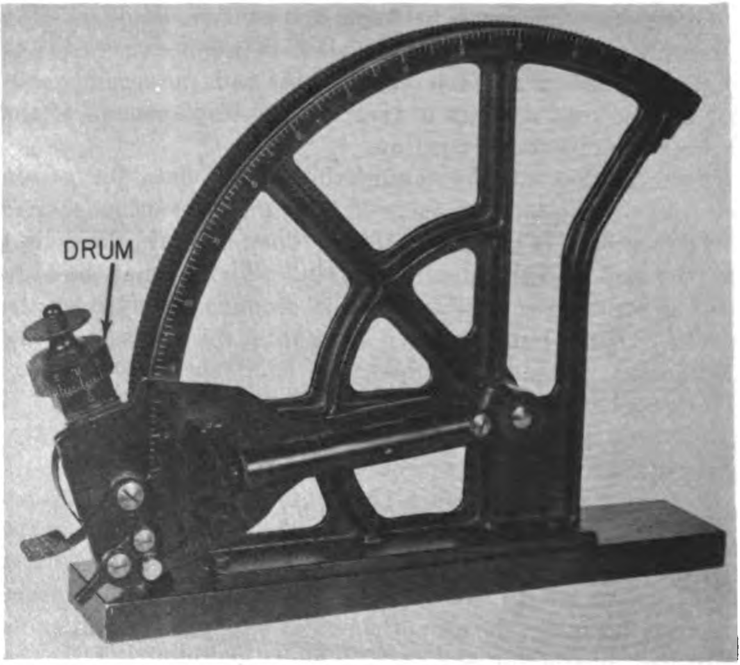


Figure 12-14.—The Mk 7 gunner's quadrant (drum type).

moving the level index arm on the arc. The spring holding the tangent screw against the arc is strong, and the teeth can be damaged if the tangent screw is allowed to snap into mesh.

The main scale is graduated as shown in figure 12-14. One revolution of the drum displaces the level arm by one degree. The finest graduation on the drum is 30 seconds and each 5 minutes graduation is numbered. Each graduation on the spirit level glass also represents 30 seconds of arc.

While the drum type quadrant is much easier to read, it has one serious disadvantage. Lost motion often exists between the worm and wormwheel assembly that drives the level arm. Since the fine reading is read from the drum, any lost motion of the tangent screw introduces an error—often as much as 20 seconds. However, the lost motion can be eliminated, if the tangent screw is always turned in the same direction when centering the bubble.

GUNNER'S QUADRANT CORRECTION SCALE

MARK 7 NO. 11 DATE 3-4-48

0	0	23	+20″	46	+1′	69	−10″
1	0	24	0	47	+30″	70	0
2	−20″	25	0	48	+20″	71	−30″
3	0	26	0	49	0	72	−30″
4	0	27	+20″	50	0	73	−20″
5	+20″	28	+20″	51	+20″	74	−20″
6	−20″	29	+10″	52	+20″	75	−1″
7	0	30	−1′	53	0	76	−20″
8	0	31	−30″	54	+20″	77	0
9	0	32	0	55	+30″	78	0
10	+20″	33	−30″	56	0	79	−30″
11	+10″	34	0	57	0	80	−20″
12	0	35	0	58	0	81	−20″
13	+10″	36	0	59	0	82	−50″
14	+20″	37	0	60	0	83	−30″
15	+30″	38	−1′ 30″	61	0	84	0
16	+1′ 10″	39	−1′ 10″	62	−40″	85	−30″
17	0	40	−20″	63	−10″	86	−40″
18	+10″	41	0	64	−40″	87	−20″
19	+30″	42	0	65	0	88	0
20	+1′	43	+40″	66	+10″	89	−20″
21	+1′	44	+40″	67	+40″	90	0
22	+30″	45	+20″	68	−20″		

Figure 12–15.—Correction sheet for gunner's quadrant Mk 7.

A second error results from inaccuracies in the teeth cut on the arc. For this reason all drum type quadrants are calibrated and a correction scale is issued with each quadrant. The correction sheet for gunner's quadrant Mk 7 (Serial No. 11) is shown in figure 12–15. Whenever the quadrant is read, the corresponding correction factor should be applied.

Adjustments of the Gunner's Quadrant Mk 7

Both the vernier and drum type quadrant must be adjusted to read zero when level before taking roller path data. Here is how you do it:

1. Adjust the bubble to correct length.

2. Select a smooth plane surface that is approximately level. Place the quadrant on this surface, and draw a line around the base of the quadrant. Center the bubble and read the quadrant.
3. Turn the quadrant around so that the inclination is measured in the opposite direction. Be sure that the base of the quadrant lies within the outline. Center the bubble and read the quadrant again.
4. The average of these two readings should be zero. If it is not, the quadrant must be adjusted (by the adjustment screw on the level tube) until additional tests show that the average of the two readings is zero.

Using the Gunner's Quadrant

The gunner's quadrant can be used for taking roller path data in a turret or mount. The roller path compensator should be set at zero before the check begins. The quadrant can be located any place in the mount or turret where it can be secured with the arc in a plane perpendicular to the roller path and parallel to the bore of the gun, and where it is in a convenient place to read. In turrets, it is usually clamped to a gun girder. It should be high enough at the forward end to avoid any minus readings; it does no harm if it is inclined at a considerable angle. The pivot end of the quadrant is placed toward the gun muzzles, so that a plus quadrant reading will indicate an angle above the horizontal. The usual procedure is to read at each odd 10° interval in train in one direction and at each even 10° interval in the opposite direction.

The procedure on antiaircraft mounts is similar. Attach the quadrant at the most suitable part of the gun or its carriage or slide. It may be placed on top of the gun, secured by lashings around the gun. The gun should be elevated slightly, to obviate minus readings. However, to avoid having data nullified by movement of the gun, it is preferable to attach the quadrant to a fixed part of the mount.

FIRING STOP MECHANISMS

It's hard to overemphasize the importance of checking the firing stop mechanisms after making the original alignment, or after doing any work or repair on the mounts or turrets that would disturb the firing stop mechanism, or in the course of routine check-ups. Every casualty from the ships firing into their own superstructures testifies to the seriousness of ANY misalignment of the firing stop mechanisms. Equally important: In EVERY case these casualties could have been prevented. They resulted from negligence on the part of the ship's personnel; or cams were cut improperly and in some cases misaligned; or the firing stop mechanisms were inoperative through lack of preventive maintenance.

As you remember, firing stop mechanisms are designed to interrupt electrical firing circuits and firing mechanism linkages whenever guns are trained or elevated to a position where firing the guns would endanger personnel or damage the ship. They should not be confused with the depression stop cams that are used occasionally to limit the movement of some guns to a safe zone of fire, or with train or elevation limit stops. Firing stop mechanisms do NOT interfere with the free movement of the gun.

The Bureau of Ordnance has issued definite instructions for the guidance of the personnel responsible for plotting, cutting, installing, and checking firing cutout cams and mechanisms. These regulations apply strictly in all cases. In addition, special instructions govern particular gun installations, for example, the firing limits of 40 mm gun mounts.

BuOrd Regulations for Firing Cutout Cams

Obviously, firing cutout mechanisms must prevent firing into permanent parts of the ship's structure. But what about movable accessories, deck gear, and rigging?

BuOrd regulations specify that when you lay out firing cutout cams, you must assume that removable parts of the ship's structure—such as stanchions, handrails, lifelines, davits—and such equipment as boats, chests, lockers, and hatches, have been removed so as not to obstruct the line of fire. BuOrd similarly does not approve of cutting cams to provide protection for forestays, halyards, radio antennae, and similar top hamper. The idea is that in peacetime, practice firing must be arranged to avoid these obstructions, while in combat, damage to them is considered a hazard that must be accepted.

Of course, some movable parts of the ship's structure, including such major items as guns, mounts, radar antennae, booms, and cranes, often cannot be turned where they will be out of the line of fire. Firing cutout cams must be cut so as to prevent fire at such parts of the ship. The same applies where personnel, such as gun crews, are unavoidably exposed to the line of fire; the cam must be cut so as to protect them.

Firing cutout cams designed in accordance with these instructions will naturally not restrict firing to prevent injury to personnel located where they are subject to muzzle blast effect, nor can they prevent damage to gear that has not been moved clear of the line of fire.

In plotting the cutout cam, remember that for guns 5 inches and larger a minimum clearance of one caliber must be maintained between the extension of the bore axis and the fixed structure of the ship. With 3"/50 and 40 mm guns the cam must provide for a minimum clearance of 8°, or 5 inches, whichever is greater.

Firing Cutouts for Bag-Type Guns 6 Inches and Larger

Most main battery guns 6 inches and larger have separate firing cutout mechanisms for train and elevation. In train, a plunger and cutout switch are located on and move with the carriage. Cam surfaces on the stand, near the roller path at relative bearings coincident with the danger area, operate the cutout switch. The elevation cutout is a flat cam and plunger mechanism mounted on the deck lug of the gun. Movement of the gun in elevation rotates the cam.

On larger caliber bag-type guns, only the electrical firing circuit is interrupted by the cutout cams. The percussion firing circuit is NOT affected. However, the cutout mechanism energizes warning lights in the mount or turret to indicate when the gun is in a danger zone and should not be fired by percussion.

The proper settings for these firing cutout mechanisms are outlined in the applicable OP's. Usually the OP's will list the settings for the individual turrets on ships of a class. After the cams are installed they must be checked by the methods to be outlined later.

Profile Cam Mechanism

In the remainder of this chapter we shall take up firing cutout mechanisms in which a disc-shaped PROFILE CAM controls the firing mechanism when the gun is in or near a danger zone of fire in either train or elevation. Such mechanisms are used on 40 mm, 3''/50, 5''/38, 5''/54, and on some larger caliber guns like the 8-inch rapid-fire. Details of these mechanisms differ slightly from one type of mount to the next, but in principle they are similar and can be considered collectively. You are responsible, as a Chief Gunner's Mate, for plotting, installing, and checking the functioning of these cams, though you will not actually cut them.

Figure 12-16, *A* shows a cutaway view of a typical firing stop mechanism plunger and profile cam; this one is from a 5''/54 single mount Mk 39. The cam turns as the mount trains at one to one speed, while the plunger mechanism moves toward the center of the cam as gun elevation increases. At minimum elevation, the plunger is near the edge of the cam. The high areas of the cam plate correspond to danger zones in which it is unsafe to fire. (You should already be familiar, from earlier courses in this series, with the mechanical linkages that operate the firing cutout mechanism.) Note that the movement of the plunger toward the center is not exactly radial, but tangent to a circle 0.814 inch in radius around the cam plate's center. (Figure 12-17 shows this clearly.)

The rise from the cutaway area to the raised portion of

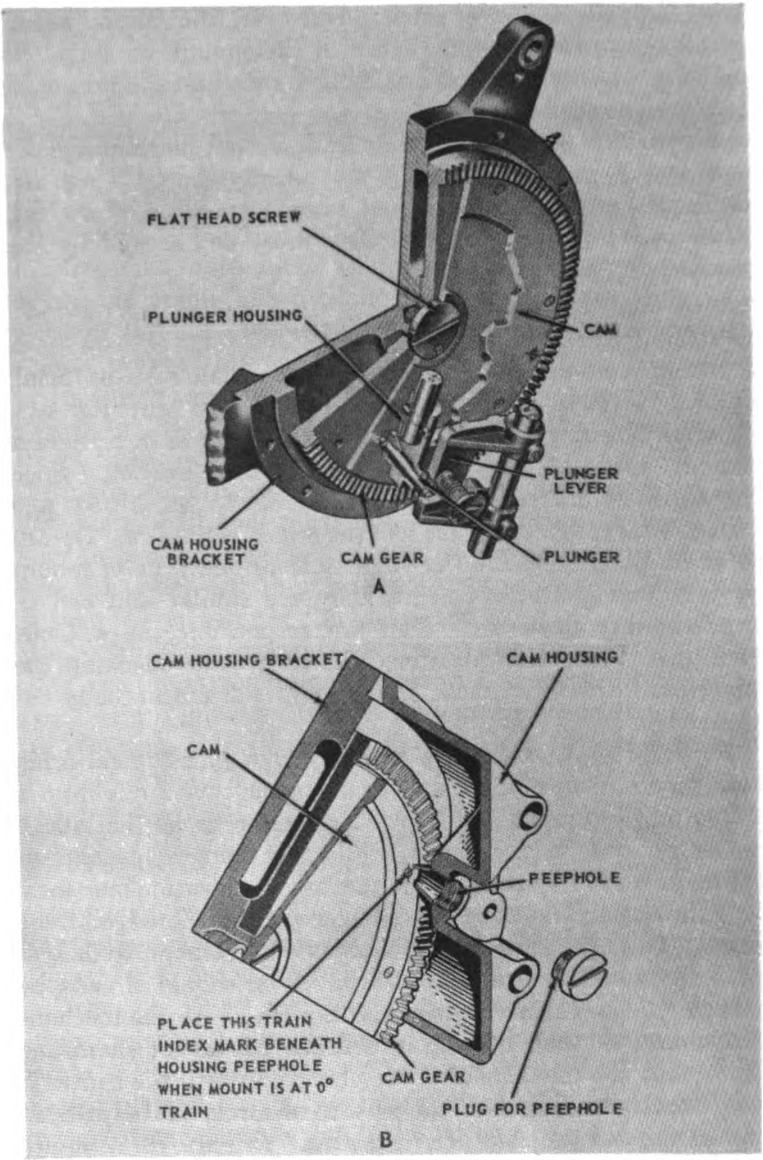


Figure 12-16.—Firing stop mechanism (5"/54 mount). A. Cutaway view of plunger and cam. B. Placing the train index mark.

the cam is a 30° incline. This permits the plunger cam follower to ride from the low surface of the completed cam to the high surface without binding, excessive wear, or scoring. Cutout occurs when the plunger is two-thirds of the way up the incline. Remember this when laying out the cam. It is necessary to scribe on the cam two additional lines, besides the line representing the danger zone of fire, to represent the top and bottom of the incline.

In tracing the safe fire zone of any mount having more than one gun, a separate cam must be traced for each gun. (An exception is the 40 mm mount where each cam controls the firing mechanism of a pair of guns. A quad 40 mm mount therefore requires two cams—one for each pair of guns.) Thus one gun of a multi-gun mount may stop firing and the other gun, or guns, will continue to fire until their firing cutout switches are actuated by their respective firing cutout cams.

Plotting the Cam on a 5-Inch or 40 mm Mount

The entire firing stop mechanism, with the exception of the profile cam, is manufactured and installed on the mount at the Naval Gun Factory. Because the profile of the cam will vary with the location of the gun, the cam must be plotted after the gun is installed aboard ship. The method of plotting the cam depends upon the type of gun. Either of two methods may be used for 40 mm and 5-inch mounts, while 3″/50's, because the cam is inaccessible, require still a third method.

METHOD NO. 1 FOR 5-INCH AND 40 MM GUNS. The main steps in this method are to map out the zone of permissible gun fire by means of a boresight in the bore of the gun; then to plot the angles of elevation at the corresponding angles of train on a cam plotting sheet; and last to transfer this plot to the cam blank. One type of sheet (known as No. 8) is used for cams that rotate COUNTERCLOCKWISE for right train: No. 9 is used for cams that turn CLOCKWISE for right train.

Here is the general procedure:

1. Install and align a boresight in the bore of each gun.

Take sights on the whole area of possible train and elevation to locate all obstacles, as required by BuOrd regulations. Take enough readings of elevation and train angles to outline accurately the zone of permissible or safe gun fire.

2. Mount the cam blank on the cam gear and dowel it in place. With the mount at 0° train and all shafts to the firing cutout mechanism fully coupled and pinned, insert a machinist's scribe through the peephole in the cam housing and mark the cam blank with a circle and cross. (Fig. 12-16, *B*.)

3. Remove the cam blank from the cam gear. With a scribe and straight edge, draw a radial reference line across the face of the cam through the geometrical center of the cam and through the cross at the center of the circle marked in step 2. Draw a second radial line through the center of the cam, but perpendicular to the reference line.

The next step is to transfer the elevation and train readings to the cam blank. For this purpose you use blank cam plotting sheets, which are the same size as the cam blank. These are furnished each outfitting yard; you can request additional blanks from the Naval Gun Factory. (When ordering blanks, be sure to specify the bore, length in calibers, and mark and mod of the gun, and whether the cam turns clockwise or counterclockwise for right train.)

Figure 12-17 shows a sample cam plotting sheet (reduced in size, of course) marked for a 5"/38 gun. The concentric circles represent gun elevations in 5° units; the table at the bottom of the sheet indicates the radius in inches from the center of the diagram for each 5° elevation. The radiating lines represent mount train angles. The train angle bearing lines are not truly radial; as we saw a few paragraphs earlier, the plunger, as it travels across the cam, follows a line tangent to a circle of 0.814 inch radius struck from the center of the cam. The circle and cross printed on the sheet's edge is so placed that when it's lined up with the one you've scribed on the cam blank, the position of the plunger on the cam, when installed, will correspond to the train of the gun.

Now we can go on with the fourth step in laying out the cam:

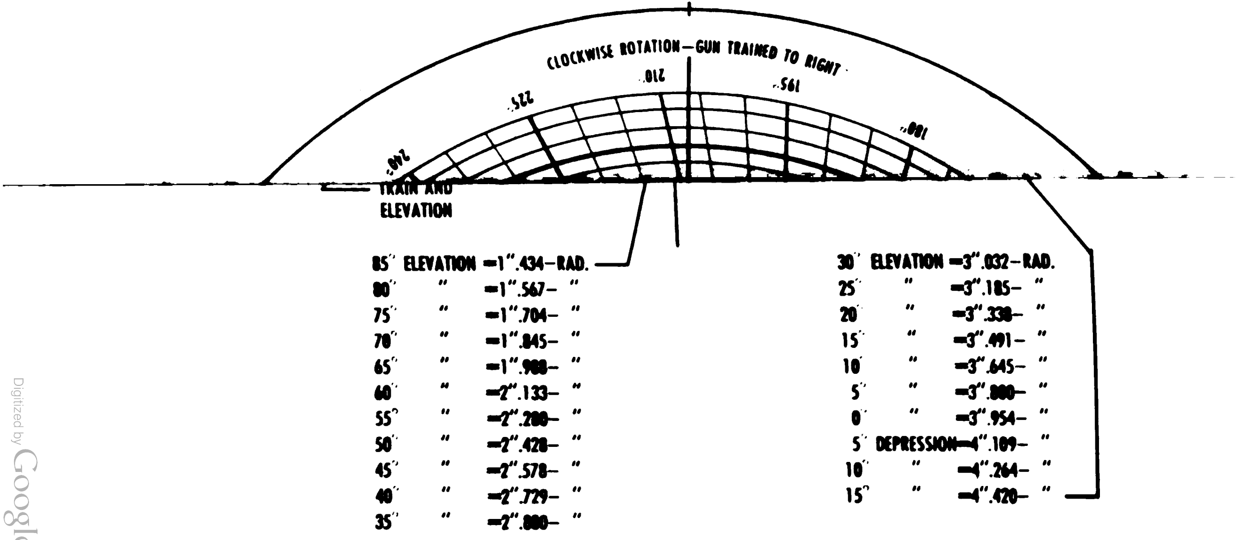


Figure 12–17.—Sample cam plotting sheet (No. 9) for 5"/38 mount.

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4. Fasten the plotting sheet on the cam blank so that the center line and cross printed on the sheet coincide with the center line and cross scribed on the cam. Then you plot the outline of the firing zone on the sheet, using the readings taken in step 1. Use the circles and radiating lines on the sheet to give you the coordinates of each point to be plotted. For example, suppose you want to plot a point at 55° elevation and 270° train. The table shows that you plot 55° elevation on the circle 2.280 inches from center. Set a pair of dividers at 2.280 inches; then, basing one leg on the center of the plotting sheet, swing the other until it intersects the 270° bearing line. Mark this point. Continue with the remainder of the readings, until all are plotted.

5. You now have a series of points on your plotting sheet. Connect them with a smooth curve. The outline you now have represents the safe and the danger firing zones. But you know that there must be a 30° incline between the two. You must plot lines representing the top and the bottom of this incline. The line you have already plotted may be considered as being about two-thirds up the slope. On a 5″/38 cam, the outer line (representing the top of the slope) is about 0.072 inch from the line you have already plotted; the inner line (base of slope) is about 0.144 inch from the plotted line. With other mounts, you should follow the instructions in the OD to fix the positions of the inner and outer lines. In any case, however, you must ALWAYS measure the distances between the lines on a PERPENDICULAR to a tangent drawn to the plotted line, at each plotted point. Figure 12–18 illustrates the general idea.

6. To transfer the plotted lines to the cam blank, use a center punch.

METHOD NO. 2 FOR 5-INCH AND 40 MM GUNS. In this method, instead of taking observations, noting down the coordinates, and plotting the profile from them, you use the firing stop mechanism itself to trace out the profile right on the blank cam. Here are the details:

1. With the mount at 0° train, remove the cam housing, secure the cam to its gear, and put it in place. Replace the

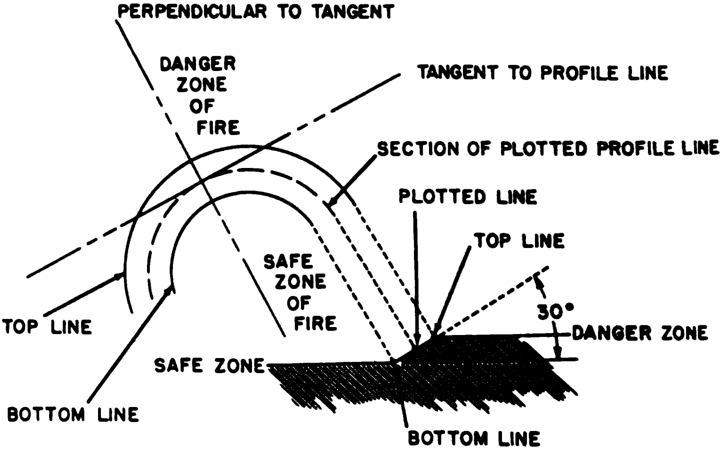

Figure 12-18.—Plotting the top and bottom lines on a firing cutout cam.

plunger that normally rides on the cam with a marking pin or scribe of the same diameter, but from 0.10 to 0.20 inches shorter in length.

2. Reassemble the cam housing, and couple and pin all shafts. Install the gun's boresight.

3. With all connections made, and the mount at 0° train, scribe the circle and cross on the blank cam as was described in method No. 1.

4. Next, with the mount at 0° train, run the gun to the maximum elevation. With the gun at maximum elevation, train the gun through its entire arc of train returning to 0° train.

5. Now depress the gun to maximum depression and again train the gun through its entire arc, returning to 0° train. This establishes exact lines of reference for 0° train and for maximum elevation and depression.

6. Starting at 0° train and maximum depression, train the gun until the line of the bore, using the boresight, intercepts the first part of the non-firing zone. Beginning at this point and using extreme care with the elevating and training gear, follow the outline of the ship's structure, sighting down the bore as before.

7. The line thus traced on the cam blank by the pointed pin should be considered as being approximately two-thirds of the way up the 30° incline of the cam. Additional lines representing the top and bottom of the incline should then be inscribed on the cam.

In both methods of marking the cam blank the actual profile line is very likely to take a course too jagged to follow when the cam is machined. You must consider this when laying out the cutting lines. The lines can be materially straightened without much loss of firing area. Of course the firing cutout cam is designed for safety, and safety is the first factor to be considered when deviating from the actual profile line.

Each cam should have an identification stamp. The information on it should include the name of the ship, and the number and location of the gun for which it was made.

It may not be possible or convenient to use 0° train as the registration point for the circle and cross of the cam. In this case any convenient angle may be used, as long as the value of that angle is inscribed on the legend of the cam. For example, if the gun is on 270° bearing when the circle and cross are inscribed on the cam, the legend on the cam should specify: "INSTALL AT 270° TRAIN." Subsequent reinstallation of the cam should be governed by this legend.

Plotting the Cam on a 3"/50 Rapid-Fire Mount

On the 3"/50 rapid-fire mount the profile side of the cam is toward the inside of the cam case. It is therefore impossible to scribe it directly. Instead, proceed as follows:

1. Remove the cam case cover, the blank cam, and the cam follower pin. Insert in the pin's place a cam tracer pin, with its point toward the inside face of the cam. Attach the tracer pin spring and secure it under the head of the screw intended for that purpose in the cross feed block. Replace the blank cam and secure it in place. Do not replace the cam case cover, because the switch pushrod must be accessible for this operation.

2. Train and elevate the gun so as to follow the outline of the non-firing zone of the cam. Trace the zone outline on the cam by tapping the switch push pin lightly with a rawhide mallet between movements of the gun. (Fig. 12–19.) Be sure to allow a minimum clearance of 5 inches between the line of fire and the edge of any obstruction.

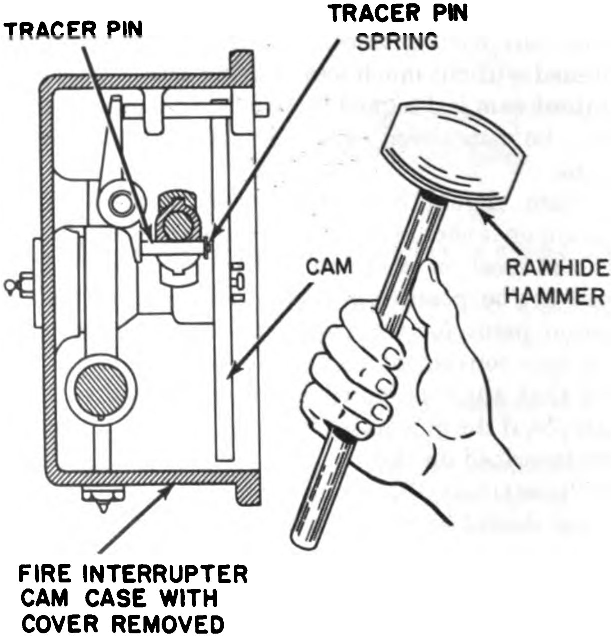

Figure 12–19.—Cam layout procedure on the 3"/50.

After plotting a cam by any of the methods above, you turn it over to the yard for machining. When the machine work is completed and the cam is returned to the ship, it must be oriented and installed according to the instructions contained in the ordnance publication on that type of mount. (See OP 0 on this.)

Finally, you must check the accuracy of the cam profiles and the adjustment of the firing stop mechanism. Following is a suggested procedure. (The voltmeter recommended may be replaced by an electric lamp of the correct voltage rating, if desirable.)

1. Make sure that the gun is NOT LOADED.
2. Lay the gun so that it is OUTSIDE of a danger zone.
3. Complete the firing circuit as for local firing.
4. Connect a suitable standard voltmeter between the firing pin and ground, or across the terminal of the firing cutout switch. Do NOT use a vacuum tube voltmeter.
5. The voltmeter will indicate full firing circuit voltage, if the circuit is completed properly (as it should be).
6. Lay the gun so that it is WITHIN a danger zone. The voltmeter should now read zero.
7. Train and elevate the gun in and out of the firing zone at various points. Check to see that the operation of the firing stop switch, as indicated by the voltmeter, occurs at the proper points.
8. If percussion firing is also included in the cutout mechanism, check to see that the percussion firing mechanism cuts out whenever the switch in the firing circuit opens. If a voltage is present in step 6, or during step 7 when the gun is in a danger zone, FIRST check for a defective firing stop switch, a defective or short circuited plug, or faulty cable insulation. If they check out OK, then you may suspect the firing stop cam layout.

This chapter has presented basic information on firing stop mechanisms for 40 mm, 3″/50, and 5-inch mounts. For details on disassembly, installation, and reassembly of the components of these mounts that are concerned with firing stop mechanisms, you must consult the OP's dealing with the mounts. For further details on the procedure for plotting and making the cam plates on 5-inch mounts, see OD 2071 and OD 3486. For information on main battery firing stop mechanisms, see OD 3222. And, of course, you must, as always, check with OP 0 for the latest current technical source on the subject.

CONCLUSION

In this chapter we have taken up the general objectives and methods of battery alignment, and have discussed in more detail certain specific operations in the whole complicated process for which you will be responsible as Chief Gunner's Mate. The problems of battery alignment which you will actually encounter will vary with the type of ship and battery you are assigned to, of course. All the answers are not in this chapter. See OP 762, *Alignment of Ordnance Installations Aboard Ship, General Instructions*, for a rather full treatment of battery alignment both ashore and afloat. (As of this writing, a revision of this ten-year-old book is in progress.) If you can obtain a copy, you will also find OGS 12, *Alignment of Ordnance Installations*, a useful reference source. (OGS 12 has been reprinted and issued by Commander, Training Command, Pacific Fleet, as TraPac 101.)

QUIZ

In each of the following, select the BEST answer.

1. In general, the purpose of battery alignment is to adjust the guns of the battery so that the lines of sight of gunsights and directors, and the bore axes of the guns, with no ballistic or parallax corrections introduced,
   a. converge at mean battle range
   b. are parallel to each other
   c. converge on the target
   d. are parallel to the deck plane
2. In preparing for battery alignment in drydock, the first step is to
   a. establish the centerline
   b. establish the deck plane
   c. level all roller paths
   d. boresight all guns
3. In battery alignment in drydock, the purpose of establishing the center of rotation of each trainable element is to
   a. establish the offset centerline
   b. determine the point of zero parallax
   c. measure the element's true train angle
   d. establish an accurate value for sight deflection

4. In general, the purpose of battery alignment in elevation is to adjust the battery so that, at any angle of train and elevation, the lines of sight of directors and gunsights and the bore axes of guns will, if ballistic and parallax corrections are not made,
    a. converge on an air target at mean battle range
    b. be parallel to the ship's centerline
    c. be elevated by exactly the same angle above a common reference plane
    d. be exactly parallel to a plane perpendicular to the deck
5. The relationship between the gun mount roller path and the reference plane is defined by
    a. the position of the battery director
    b. the amount and direction of greatest roller path tilt
    c. the amount of deck tilt when the ship is drydocked
    d. none of the above
6. Which of the following statements regarding horizontal parallax correction (applied to gun mounts) is NOT true?
    a. It causes the gunsight line of sight to converge on the director line of sight.
    b. It increases with decreasing range.
    c. Standard correction is based on gun to director distance of 300 feet.
    d. Amount of correction is shown on the train angle dial.
7. The purpose of the horizon check is most often to
    a. measure the difference in dip angle between the gun mount roller path and the director
    b. measure the amount and direction of pitch and roll by sighting the director on the horizon
    c. determine the amount and direction of tilt of the reference plane with respect to the director roller path
    d. determine the amount and direction of gun mount roller path tilt with respect to the reference plane
8. In a horizon check, the least difference between the director reading and the gun elevation reading indicates the
    a. high point of the gun roller path with respect to the director roller path
    b. low point of the gun roller path with respect to the director roller path
    c. point of zero roller path error
    d. point of minimum roller path error
9. Which of the following data are shown on the sine curve plot of horizon check data, but not on the radial (circle) plot?
    a. Inclination at low point
    b. Bearing of low point
    c. Constant error
    d. Observational error

10. In the roller path compensator shown in figure 12–10, scale B is used to
    - a. determine the bearing of the point of maximum tilt
    - b. set the amount of maximum tilt
    - c. measure the amount of roller path tilt at any train angle
    - d. indicate the level of the true reference plane at all times

11. On which of the following indicator-regulator dials does roller path correction register?
    - a. Zero-reader
    - b. Follow-the-pointer
    - c. Elevation angle reader
    - d. None of the above

12. Suppose you find from the horizon check that the roller path tilt is 4′ at 031°, but the present compensator setting is 2′ at 165°. Of the following four, which is most nearly equal to the proper setting?

    (*Note to Student.* Better work this out. If you don't work it out properly, you're likely to get one of the three wrong answers.)
    - a. 3′ at 060.5°
    - b. 6′ at 196°
    - c. 2.5′ at 239.5°
    - d. 2′ at 345°

13. The angle indicated in figure 12–13 is (*Note.* Graduations match where indicated by the black arrow in the figure)
    - a. 3° 9′ 18″
    - b. 9° 18′ 40″
    - c. 10° 33′ 20″
    - d. 9° 15′ 3.6″

14. When you plot firing cutout cams, BuOrd regulations require you to plot them to prevent fire at
    - a. radio antennae
    - b. cranes
    - c. davits
    - d. any of the above

15. When plotting a firing cutout cam, you should sight at the ship's superstructure through the
    - a. peephole in the firing stop mechanism housing
    - b. pointer's sight
    - c. trainer's sight
    - d. boresight telescope

CHAPTER 13

SAFETY

YOUR RESPONSIBILITIES IN SAFETY

When you first became a striker for Gunner's Mate, safety was a big part of your training both in school and aboard ship. Safety played no less a part when you finally did make Third Class . . . and Second Class, too. Don't be surprised to find that safety still plays a big part in the job of both the First Class Gunner's Mate and the Chief Gunner's Mate. In fact, it's a bigger part, in one very important way. As you've risen in rate, you've acquired supervisory responsibilities. Being a boss isn't just a matter of ordering people around. You're RESPONSIBLE for them, too. It isn't enough for you to cultivate safe working methods yourself. That protects you, and it even sets a fine example, which is worth while. But it isn't enough for the First Class or Chief Petty Officer. Those extra chevrons on your arm mean, among other things, that you have got to see that EVERYBODY you supervise knows the safe things to do, and does it. The finger is on YOU.

It's Good—and You Can Enforce It

Remember that wisecrack about Prohibition? It's the one that went "It's good, but you can't enforce it." That may have been true for the "noble experiment" years ago, but it's not true of your responsibilities regarding safety.

Safety is good, and you CAN enforce it. You MUST enforce it. The Navy stands behind you in this. With the responsibility you have for the safety of those under you—and for the safety of your ship—you have also the authority to enforce safe working methods.

As will be brought out very shortly, you should so train your men that they use the safe method, by preference, as the BEST method. You should not, usually, have to wave your stripes to enforce safety. Yet you will encounter the individual who, through inability, incompetence, or just plain cussedness, cannot or will not follow the safe methods prescribed. What specific action to take with such a man will depend on the circumstances you're in. Often you won't find it necessary to put the offender on report; it may be sufficient just to transfer him to some other job. But if you find you must, you should not hesitate to put on report the safety violator who knows better, who can do better, but who just won't. If you don't enforce safety rules, you're as guilty of their violation as is the actual offender, and you're endangering your ship and your men as much as he is. So it's up to you to enforce safety, and make it good.

Safety and Training

Fortunately, the character who, because he is either hardboiled or softheaded, makes safety enforcement difficult, is a pretty rare bird. Most men will gladly go along with safety rules if the rules make sense to them. This is especially true if safety habits and adherence to safety rules are made a part of training. That's why it is so important to train your men in the SAFE way of performing all the operations that are part of their job. Sometimes you may have to get them to UNlearn unsafe habits that they have picked up. And your job may also be complicated by the fact that the safe way often requires extra operations, delays, or preliminaries that the thoughtless or the lazy man is likely to overlook, or intentionally omit, or lack the ingenuity to perform. But even the thoughtless and the lazy can be trained to safety habits. If they can't, they have no business on your team.

It's been said that safety is a state of mind. That's true in at least two senses.

One sense has to do with knowledge. Obviously, a man can't do his job the safe way if he doesn't know how or doesn't know about the safety regulations regarding the work. That's pretty easy to remedy: You tell him or teach him how to do the job the safe way, or you tell him about the regulations—especially those of local origin. A slightly more difficult case is that of the experienced man who has developed sloppy work habits because he's been doing a certain kind of job too long, or who feels he knows all there is to know about a certain kind of job or equipment. Well, he may know a lot, but most of it may be dead wrong. Such a man may have to do a certain amount of unlearning before he can be taught the proper methods.

The second sense in which you can say that safety is a state of mind is what we can call MENTAL ATTITUDE, as contrasted with knowledge. The "know-it-all" character we've just mentioned comes under this interpretation because coupled with knowing the wrong things is his unwillingness to learn the right ones. So it's most important that your men be SAFETY-MINDED. It isn't enough to say "If I see you violate this safety rule, you'll be court martialed." True, there are times when you can't avoid saying something like that, but what you should aim for is a mental attitude on the part of your men that recognizes the need for safety rules, plus habits of work that make adherence to the rules as nearly automatic as possible.

That's more realistic, too. To threaten with court martial or captain's mast a man who is mishandling ammunition, for example, is a little like the situation of the fellow in the story who accidentally dropped an atom bomb. It didn't go off, but somebody else shouted at him: "Easy there, butterfingers! That stuff's dynamite!" Anybody who is careless with ammunition is likely to have something much worse than captain's mast or court martial to worry about.

WHERE TO FIND SAFETY PRECAUTIONS

It's up to you to keep up with regulations regarding safety that apply to the work done under your supervision in the gunnery department. On the whole, this is not too difficult. There are several easily available sources of information on safety.

Technical Publications

First of all, there are the technical publications.

For ordnance equipment other than ammunition, the most important of these are the OP's, of course. You don't often find a whole chapter in an OP dealing with ordnance equipment that's headed SAFETY. Safety precautions and safety methods are so intimately tied up with the operation and maintenance of ordnance equipment that they are scattered throughout the book. Look for them especially in sections dealing with operation, maintenance, repair, trouble-shooting, disassembly, and reassembly of the equipment. Safety precautions are not so likely to come up in sections on the theory, operating principles, or functioning of the mechanism.

With ammunition, it is a little different. Electric motors, mechanical linkages, power drives, gear trains, hydraulic systems—and even the guns themselves—are just so much machinery, and present to their operating personnel hazards similar to those in, let's say, the ship's machine shop or engine room—except that the engine room may have additional hazards like high-pressure steam or carbon monoxide fumes that you won't find in a gun mount or turret. You don't even have to be aboard a naval vessel to be exposed to such perils; a steamfitter's job in a factory ashore, or that of a laborer in a steel mill, is even more hazardous. These are all what you might call INDUSTRIAL types of risks. But, with ammunition, as we have said, it's a little different. Ammunition is INTENDED to blow up and destroy.

So we find that publications on ammunition pay particular attention to the matter of safety. You are already aware of how much safety is emphasized in almost any publication or training aid dealing with ammunition—and it deserves to be.

This is not to say that you should neglect what we have called the industrial type of safety; but, because ammunition is intended to be destructive, the casualties resulting from an accident involving ammunition are likely to be much greater than when ammunition is not involved.

BuOrd Publications on Safety

In general, the best source of safety information on any type of ammunition is the ordnance publication for that ammunition. You will find some general ammunition safety information in OP 4, *Ammunition, Instructions for the Naval Service Afloat* and OP 5, *Ammunition Ashore*. Both of these concentrate almost exclusively on gun ammunition, but the editions available at this writing are not entirely up to date with regard to certain topics like propellent powder testing.

You will also find it instructive, if sometimes harrowing, to read OP 1014, *Gunnery Safety Precautions, Their Origin and Necessity*. A good deal of this pamphlet, which is a reprint of a lecture first delivered in 1925 by LCDR (later RADM) W. H. P. Blandy at the Naval Academy, is concerned as much with guns as with ammunition. The passage of time has modified the applicability of some of it, but you will find it a revealing account of the present applicability and past history of many of the safety precautions you still are obliged to comply with today. OP 1014 has been widely quoted and reprinted in part in many other publications, so it's not likely to be one hundred percent new to you; but, if you have not yet read it, you should. If safety is a state of mind, OP 1014 will put you into it.

Another OP on safety you should be familiar with is OP 1591, *Clearing of Live Ammunition From Guns*. Some of this has been modified by OCL's and other publications since its original issue in 1945, but you will find its suggestions valuable.

If you are concerned with demolition work, see OP 1411, *Safety in Combat Demolition Installation and Blasting for Underwater Demolition Teams*, which not only is an excellent source of information on demolition techniques, but also contains a comprehensive chapter on safety in demolitions. Some of the same information is presented in the chapter on demolitions in this course.

One other Bureau of Ordnance publication, issued as an unnumbered pamphlet with the title *Safety Precautions*, is important because it was issued in 1948 to substitute for Article 972 of *U. S. Navy Regulations*, which has been revoked. Its content has been brought up to date to some extent, but it is not as complete as other sources of safety information mentioned elsewhere in this chapter.

Besides all of these, there is the *Bureau of Ordnance Manual*, which contains chapters on ammunition stowage and handling which deal, in passing, with safety in this connection.

Besides OP's, there are other Bureau of Ordnance publications dealing with safety. Your best bet is the subject index in OP 0, which has a heading on safety. And keep up to date with new technical publications as they come to you.

Other Publications on Safety

As you know, BuOrd is not the only source of publications dealing with safety. Safety is a highlight of Navy training courses issued by the Bureau of Naval Personnel. You know that just from studying the courses in this series. But there are other BuPers publications that take up this subject, too. Listed below are those that you will find most valuable.

1. *Ammunition Handling*, NavPers 16194. Although not all the ammunition described in this book is still in service, it still is a useful encyclopedia of information on ammunition, including its handling and safety.
2. *Naval Ordnance and Gunnery*, NavPers 16116–B. This valuable book has an appendix in which are summarized the standard safety rules regarding naval guns and ammunition.

3. *United States Navy Safety Precautions*, OPNAV 34P1. The safety precautions contained in this publication are promulgated for the protection of military and civilian personnel in all parts of the Naval Establishment. This publication has the objective of stimulating an effective safety and health program throughout the Navy by including, in one central and authoritative publication, those safety precautions which will ensure a working enviroment conducive to good health. The use of this publication by all hands is strongly encouraged.

Especially if you are assigned to duties involving handling or stowage of ammunition or explosives at a station ashore (such as a depot, proving ground, or factory), you will be using for reference, besides the publications already mentioned, publications on safety issued by agencies other than the Navy.

One well-known source book of this kind is the *Ordnance Safety Manual*, issued by the U. S. Army's Ordnance Corps as ORD M 7–224. It contains plans for constructing magazines ashore, rules for safe storage distances and allowable concentrations of explosives stored ashore, summaries of the characteristics of common military explosives, safety procedures for proof testing of ammunition, and so on. Of course, you will abide by the safety rules prescribed by competent authority aboard the station. However, since you will, as a Chief Gunner's Mate, be considered one of the authorities on ammunition, you may well have a hand in making up or amending the safety rules, and the *Ordnance Safety Manual* will prove most valuable for this purpose.

You will also do well, if your duties include demolition work, to have a copy of the latest edition of the *Blaster's Handbook*, issued by the DuPont Corporation. This is a standard guide to the characteristics and utilization of commercial types of demolition explosives.

Safety Placards and Name Plates

The published sources of safety information we have mentioned above will be useful not only to you but also to the men working under you. See that they are available, and that your men use them. But there are written sources of safety information that are not books: signs, placards, and name plates.

Many placards and name plates are prescribed. They must be displayed on the gun mount as prominently as a hacker displays his license to his fares or a doctor displays his diplomas to his patients. There are many examples of these. For example, EVERY gun slide with a hydropneumatic counterrecoil system MUST bear a clearly lettered and permanently affixed plate warning against the use of oxygen for charging the system. And that's only one of many. The OP's on each mount or turret, and associated equipment, will prescribe the wording and location of these essential warning plates.

Besides these, there are posters, placards, and signs that are either optional or may be required by the gunnery officer, by the skipper, or by other commands. One example is the lists of safety regulations published by DesLant to be posted in 5-inch gun mounts. There are many others. And, with the permission of your gunnery officer, you can add still others as required. It's your business to keep up with *NavOrd Instructions* and other issues from competent authority to know what is required along these lines.

In addition, there are purely temporary printed notices which are usually cards or tags. Again, it's your responsibility as a Chief or First Class Gunner's Mate to see that temporary warning tags are available to your men and that they use them. One common example of the kind of tag there should always be enough of is the familiar red one that you tie to an open power switch or fuse box to warn everybody NOT to close the circuit while working personnel can be endangered.

These and similar tags are items in plentiful supply and should be easily available. If for some reason, they're not, get the ship's printer to make some up for you (if you're on a large ship or can get to a tender). If you can't get them printed, improvise them yourself. But be sure your men have them and use them.

SAFETY DIGEST

If you haven't by this time developed a good, firm grasp on this whole subject of safety, this is clearly no time to begin. And this chapter certainly cannot give it to you. But now that we have indicated the main sources of information on safety, it may be useful to review the subject by means of this safety digest. Of course, so brief a review can be little more than a spot check, but it is intended as just that. If you're shaky on anything we take up in it, that's a sign that you need some intensive reviewing in the source materials we have mentioned above.

Safety Precautions Ashore

Let's begin with safety ashore.

We generally think of Gunner's Mate as a seagoing billet. Yet, you need to know the general rules involved in stowing and handling ammunition ashore, whether at a depot, a distribution point, or an advanced base. If you have a long tour of shore duty, you will become well acquainted with OP 5, *Ammunition Ashore;* it is a thick and meaty book. The paragraphs below merely mention a few outstanding topics.

MAGAZINES. Ammunition magazines in the continental United States are built according to strict safety-distance specifications. Each is clearly marked and is reserved for a specialized type of ammunition. Rigid prohibitions are enforced against fire hazards of all types. Inspections are frequent and thorough. Every effort is made to keep the large quantities of dangerous material from becoming a threat to our own men.

Magazines at ADVANCED bases seldom meet all the requirements in force at stateside stowage points. This is true especially in the hard and dangerous days when a new base is being set up. Yet, even under rugged pioneer conditions, the ammunition-handling crew must stow all explosives as safely as possible, segregating types and lots, eliminating fire hazards, and improvising protection against sunlight, water, and excessive cold or heat. As soon as conditions permit, the officers and men responsible for ammunition stowage at an advanced base must improve the magazine areas to meet Bureau of Ordnance requirements, whenever this is possible.

TRANSPORTATION. Long-distance overland transportation of ammunition is governed by regulations issued by the Interstate Commerce Commission's Bureau of Explosives, and other Government authorities. Short-distance transportation may require trucks, cranes, pulleys and slings, hand methods, and various combinations of these. What equipment you use depends on where you are stationed, what type the ammunition is, how it is packed, and what its special dangers are. Regardless of what equipment you use, YOU must check it for safe working condition BEFORE actual operations begin.

Whenever and wherever you are moving ammunition, one old general rule holds good: Take time to work carefully and safely. Dragging, jolting, dropping, bumping—all can start explosions. Direct sunlight, exhaust gas, heat, and static electricity are danger elements. Protect the ammunition from all these general hazards. In addition, know and enforce the special rules that apply to the given type of ordnance and the given work situation.

AT THE PIER. Procedures to use and dangers to avoid in embarking or disembarking ammunition are given in *Gunner's Mate 3*, NavPers 10181. As you direct ship-loading operations, you will need to be attentive to such things as the proper use of warning signals, the enforcement of the no-smoking rule, and the intelligent selection of working groups. Choose as few men as the job permits, and try to get the best men for the job. Be sure that each man understands exactly what is expected of him. Once again, tell your crews that ammunition handling is no occasion for a relay race.

Above all, be alert yourself; while you enforce the rules, set a good example.

Shipboard Magazine Precautions

By now, shipboard magazines have become an old story to you. Is it possible, perhaps, that they are too much of an old story? For example—

Do you know all the ins and outs of your ship's sprinkler system? Could you put it to work in a hurry? What other firefighting equipment does the ship carry? Where is it? How is each item used—and why?

Have you personally verified that the magazine housekeeping is a hundred percent up to snuff? Or is there an oily rag back in the corner behind the 5"/38 projectiles? Are the repair-parts boxes really used for the listed spares, and for no other purpose? Is every placard in its proper place?

Do you know the special hazards involved in stowing bombs, underwater ordnance, and other ammunition outside your own line of work? Do you know what danger signs to look for when you inspect these weapons? Can you give your men clear, satisfactory reasons for the rules requiring that you segregate such items as detonators, photoflash bombs, and rocket motors? It isn't enough to say: "It's always been done that way, so we don't need any reasons."

Do you teach and practice safety precautions when cleaning and repainting are required? Are you alert to see that these operations are carried on only in the assigned spaces, with the authorized tools, in accordance with Bureau of Ordnance instructions?

We could go on indefinitely with this check-off quiz. By this time, however, you have the general idea. Form the habit of tripping yourself up with a short quiz of this sort when you feel things settling into a rut. FAMILIARITY BREEDS CARELESSNESS, unless you keep on the ball.

Operating Precautions

When you were a striker, you learned about foul bores, flarebacks, misfires, hangfires, and cook-offs. You learned why each of these is dangerous, and what you must do if it occurs or threatens. You also received warning that doing no more than training or elevating a gun, without proper safety precautions, can in itself be a hazard.

Now you know from experience what precautions to take in hoisting and passing ammunition, as well as in loading, aiming, and firing the guns. You have spoken with authority on some phases of the work, and have instructed new hands assigned to the crew. But as First or Chief you will have broader responsibilities. In fact, you will be expected to know ALL the answers.

Knowing all the answers is a large order, especially if, for example, you are working with one of the new rapid-fire 6-inch or 8-inch guns. The Bureau of Ordnance considers each of these new gun types important enough to warrant a 6-volume publication. The Navy also gives specialized training courses to Gunner's Mates working with these and other complicated guns. Perhaps you have taken such a course, or have been slated to do so. At any rate, you will need to study the proper OP on your gun. Don't be afraid to tackle the harder topics, such as fire control equipment. They aren't your specialty, but the more you learn about them, the better you will understand how your own work fits in.

Here, in brief summary, are some of the things you should know so well that you practice them automatically in gunnery exercises:

1. Keep all mount and turret safety devices in good working condition at all times.
2. When a power-driven unit is being operated, and the operator cannot see all persons and equipment in the unit's path, a safety watch must be maintained, except at general quarters. Some means of voice communication must be set up between the operator and the safety watch.
3. Whenever an enclosed turret is trained, the bell, buzzer, or other warning signal must be sounded, except at general quarters.

4. Never use ammunition in a caliber or type of gun or projector for which it has not been specifically designated.
5. Don't tap or strike fuzed projectiles.
6. Make sure that flameproof integrity is maintained at ALL points along the ammunition's line of travel from the magazine to the gun. This is especially important in turrets with bag ammunition.
7. Never allow more than the necessary minimum of ammunition to accumulate at the gun or at any point along the route.
8. Don't load live ammunition into a gun unless you intend to fire it.
9. Know the meaning and use of the BORE CLEAR signal. Never use it until the bore really IS clear.
10. Always close the breech at once after loading the gun. This, like No. 6 above, is especially important on bag guns whose breech mechanisms do not close automatically on loading.
11. Know and practice all the special safety precautions that apply to the loading and firing of any type of gun.
12. Mark the recoil position of the breech housing, and warn the gun crew to keep clear of the recoil area. This, too, is ESPECIALLY important with bag-type guns which recoil right into the crew area. With case-type guns, the problem is to keep fingers and hands out of the path of recoil in the slide.
13. Never use any except the authorized ramming devices and methods in loading live cartridges. Don't try to force a cartridge into the chamber. If the cartridge does not enter fully and freely, it has some deformity that makes it a hazard. Carefully extract such a cartridge and dispose of it according to the instructions issued by your gunnery officer.
14. The rules that apply to misfires, hangfires, and cookoffs are stated in *Gunner's Mate 3*. Be sure your crews know how they apply to the guns they are firing. In time of action, there is no chance to look up the answer in a book.

Rockets and Pyrotechnics

Rockets and many pyrotechnics are part of your responsibility. Both are hazardous—more so than conventional gun ammunition. Let's review rockets first.

ROCKETS. In *Gunner's Mate 3*, you were warned against thinking of a rocket launcher as being just a different type of gun. The problem of safety with rockets is different for two good reasons. One reason is that the danger area is BOTH ahead of and behind the projector. The other is the sensitivity of the ballistite propelling charge. Because of the peculiar hazards of rockets, *Naval Ordnance and Gunnery* (NavPers 10797) lays down this law: "Frequent review of ordnance pamphlets and the latest ordnance instructions pertaining to each piece of equipment should be made mandatory . . . wherever rockets are stowed, assembled, or fired." So, if your ship carries rocket ammunition, you are expected to study, and keep studying, the current technical instructions about these weapons.

Rockets are likely to fool the new hand. They look so simple that he doesn't realize their dangers. You must correct this false impression before someone gets hurt or killed. Here are some of the warnings that experience has shown it necessary to have repeated over and over:

1. Don't stand (and don't let anyone else stand) behind a rocket launcher that is being loaded and fired; that nozzle blast is HOT.
2. When you load rockets, wear long trousers and long, buttoned sleeves. (This is required uniform for most gunnery operations, anyway.)
3. Maintain and operate the firing system in strict accordance with the BuOrd rules for that mark and mod of launcher. Always keep the firing circuit open until the time of firing. It should be open when loading the launcher, during misfire procedure, and at any time when men are in the danger area of the launcher.
4. Launchers should be kept ready-loaded only when

required. Loaded launchers should be, so far as possible, protected from direct sunlight. Keep all extra rockets at a safe distance from the launcher.

5. Know and observe the rules regarding safe firing temperatures.
6. NEVER remove the ballistite grain from the rocket motor.
7. Never try to fire a rocket that has a loosened closure disc; dispose of the complete round as directed by your gunnery officer.
8. If a rocket misfires, clear the area and keep it clear for at least 10 minutes (unless otherwise directed by the CO). Then replace the fuze safety wire and dump the misfired round overboard.
9. Never expose rockets to any POSSIBLE sources of accidental sparks or flames; they ignite fast. Keep the shortcircuiting tabs on the firing contacts till the last possible moment.
10. If you are working at an advanced base, oı anywhere else under handicaps, do everything possible to give the rockets stowage in an area where the temperatures will lie within the safe firing range specified on the motor.

PYROTECHNICS. Not all pyrotechnics (fireworks) are fired from guns or gun-like projectors. Photoflash bombs, for example, are dropped from aircraft. But regardless of how they are constructed and used, all pyrotechnics are dangerous enough to require segregation and special fire-fighting methods. Here are reasons why—and you should make these reasons clear to your men:

1. Some pyrotechnics ignite spontaneously in water. This means that they must be stowed in areas specially protected from moisture. It also means that a sprinkler system is no help if they catch fire.
2. Some produce poisonous fumes when wet—another reason why they must have dry, specially protected storage, and why it is dangerous to fight fires with water if they are around.

3. Some explode with great violence and intense heat when ignited.

Bomb-Type Ammunition

Bomb-type ammunition includes bombs and other comparatively thin-cased explosive-filled devices like mines and depth charges. You deal more with depth charges than with bombs and mines, but the safety precautions for all of these are similar, as you might guess.

All these weapons have a large main charge consisting of some high explosive such as TNT or HBX. To detonate this main charge, there are one or more sensitive elements and explosive trains. In a depth charge, these are the PISTOL and BOOSTER. In a mine, we find a PRIMER, DETONATOR, and BOOSTER. A bomb has a FUZE or FUZES plus, usually, a booster.

The normal procedure in shipping and stowing bomb-type weapons is to keep the initiating device SEPARATE from the main charge. Any accidental detonation will then be a small one. Assembly of the complete unit is delayed as long as practicable, and is carried out according to specific BuOrd instructions for the given weapon.

Here are some of the other safety precautions that apply to bomb-type ammunition:

1. Detonators, if not issued as integral parts of fuzes, must be kept in special detonator lockers in approved places.
2. Electric igniters, detonators, and fuzes must be short-circuited when stowed.
3. Disassembly, repair, or any alteration of fuzes and other sensitive elements is normally forbidden. It is permitted only under special conditions covered by definite BuOrd orders or instructions. NEVER try to disassemble a sensitive element unless (a) you're qualified to do so, and (b) you have permission from competent authority.
4. Arming wires, safety pins, and all similar devices are used for the protection of our own men. All hands

assembling bomb-type ammunition must know and follow the instructions for using these safety elements.

5. Fuzes or other sensitive elements that have been set, but not used, must be restored to SAFE before they can be returned to stowage.
6. If the sensitive element has been inserted in any bomb-type weapon, treat this weapon as though you knew it to be ARMED. Even if it's set at SAFE, play it SAFE.

Torpedoes

In this course we haven't taken up torpedoes, but you have been in the Navy long enough to know that the torpedo is an expensive, complicated weapon, with at least one hazard for every complication. Only torpedo specialists work with it, except in emergencies and under supervision. You must pass on to new men the warning that they are to leave the tin fish strictly alone. Keep hands off unless, in an unusual situation, you are asked to help a torpedo expert who knows exactly what to do and how to do it.

Chemical and Smoke Munitions

Some chemical and smoke munitions are shot from guns. Others are dropped like bombs. All of them are dangerous and require the utmost care in stowage and handling. Some are harmed by moisture, the same as pyrotechnics. One rule applies to all types: They must be stowed as far as possible from magazines containing high explosives. Because the types vary and each presents unusual hazards, BuOrd supplies special drawings and instructions covering each.

SAFETY AND SUPERVISION

In this chapter we have mentioned a number of things that you already know. Remember, however, that you didn't always know them; the knowledge wasn't born with you. Many of them were part of your experience at boot camp. More of them became part of you as a result of day-by-day routine over many years. Some of them you may have learned the hard way—by bitter experience.

Remember that the lower-rated men in your crew don't know as much as you do about safety. It's good policy to assume that they know nothing except those things that you personally have taught them. Some men will gripe, but they are likely to be the very men who need repetition the most.

Remember also that, as a Chief Petty Officer, you're a leader. It's no news to you that competent leadership depends as much on what you do as on what you tell your men to do. This applies more to safety than to almost any other phase of your work. Always set the example yourself. You're not the one to dress a man down for violating the nonsmoking rules while there's a lighted cigarette dangling from your lip.

Safety applies to training as well as to actual operations, to work ashore as well as afloat. It's especially important in training, whether in school or on shipboard, because it's in training that habits are first formed and begin to take root. Besides that, it's easier to initiate safety consciousness in training because there's usually less pressure, more time, and more space. Profit by these advantages when you can, because they're less likely to exist under actual shipboard conditions.

FIRST AID

When you and your men know and practice safe working methods, you are obviously minimizing the chance of accidents. But you will not, because you cannot, absolutely eliminate accidents and injuries to your men, any more than—even with the most thoroughgoing maintenance work that is humanly possible—you can absolutely eliminate wear and breakdown in your equipment. It just isn't possible. Proper maintenance and safe, efficient working methods will save you many a headache, and it's worthwhile to make real efforts to attain them. But the time comes, sooner or later, when a man or a part falters or fails, or when enemy action takes effect, and it's up to you to see that you and your crews are ready.

We won't go into equipment casualties here. We've taken them up elsewhere, and you should prepare yourself for them by knowing your equipment and the OP's on it. But what of your men?

First aid is a fundamental part of your training in the U. S. Navy. There are certain phases of it that you should keep yourself and your men well trained in—the phases that relate to the types of injuries that men working with weapons are most likely to suffer. This isn't the place for detail on first-aid treatment; see your *Bluejacket's Manual* and similar sources of information on that topic. But here are the kinds of injuries that you should be especially prepared to deal with:

1. BURNS. These are usually caused by contact with gases from burning powder or other burning materials. It's mainly because of the possibility of burns that your men must wear CLEAN uniforms, must always keep their shirts buttoned at neck and wrists, and must keep their trouser legs rolled down. Remember always to treat seriously burned men for shock.

2. ASPHYXIATION. This can be caused not only by chemical warfare agents, but by powder fumes in enclosed mounts and turrets. That's why you must run your ventilating equipment if you possibly can (and you usually can), and it's one of the reasons why your gas ejectors must be in good order. Make sure that your men know the approved artificial respiration technique; this is worth drilling from time to time.

3. ELECTRICAL SHOCK. This is not likely to happen during action, but it's possible during maintenance operations. Be sure your men understand that even low voltages can shock a man into unconsciousness if he is wet or is standing in water. Electrical maintenance is not the job that the Gunner's Mate spends most of his time on, but what he does do he should learn to do safely. Severe electrical shock often causes respiration failure; artificial respiration is important here, too.

4. EFFECTS OF HEAT. Even with ventilators running, enclosed mounts are hot places to work in during summertime when the sun is beating down. Open mounts are no cinch

either, nor are handling rooms or magazines. So be prepared to deal with both heatstroke (heat exhaustion) and sunstroke, especially when some of your men are new and not yet accustomed to these conditions. Make sure they can distinguish between heatstroke and sunstroke, and know the proper treatment for each.

5. FRACTURES AND HEMORRHAGES. These by no means are caused only by enemy action, so your men must know how to deal with them at all times. Be sure they can recognize obvious fractures and know what to do about them. They should know how to locate pressure points, how to distinguish between venous and arterial blood, and how to apply simple dressings and tourniquets.

CONCLUSION

This course, like others in this series, both begins and ends with safety. In it you have studied subjects that you, as a Chief or First Class Gunner's Mate, are expected to master. Most of what you have studied is directly related to the examination subjects for the Chief and First Class Gunner's Mate rates; some of it will provide background that will help you master the practical factors.

You will find that this course will be valuable to you later on as a reference for information relating to your work. But it is primarily intended for your study in preparing for promotion. Be sure to supplement it with the other study materials mentioned elsewhere in this course.

And be sure to work the quizzes; remember to use them as spot checks, not as thorough reviews.

If you have done all these things, you are ready to take the promotion examination—and pass it.

QUIZ

In each of the following, select the BEST answer.

1. The PRIMARY source of information on safety precautions for ordnance equipment (other than ammunition) is usually the
    - a. *Navy Regulations*, article 972.
    - b. ordnance pamphlet on the gear
    - c. *BuOrd Manual*
    - d. check-off list
2. Information on construction of magazines ashore appears in
    - a. OP 5, *Ammunition Ashore*
    - b. *Safety Precautions*
    - c. *Naval Ordnance and Gunnery*, NavPers 10798
    - d. *Bureau of Ordnance Manual*
3. If your 5-inch power rammer is in working order, but cannot push a cartridge case into the breech, the safe thing to do is to
    - a. hammer the case home with the rawhide maul
    - b. drive the case in with a crowbar
    - c. grease the case so it will slide in more easily
    - d. extract the case and set it aside
4. When may the ballistite grain be removed from the rocket motor?
    - a. While the head is being fuzed
    - b. In case of misfire
    - c. If the rocket has been exposed to excessive heat
    - d. None of the above
5. Which of the following injuries may, when severe, require artificial respiration?
    - a. Heatstroke
    - b. Bone fracture
    - c. Electrical shock
    - d. Burns

APPENDIX I

ANSWERS TO QUIZZES

CHAPTER 1

SOURCES OF INFORMATION

1. c
2. c
3. d
4. a
5. b
6. a
7. b
8. d
9. c
10. b
11. d
12. a
13. a
14. c
15. a

CHAPTER 2

MAINTENANCE, REPAIRS, AND ALTERATIONS

1. d
2. c
3. a
4. a
5. c
6. a
7. b
8. a
9. a
10. c
11. b
12. d
13. c
14. b
15. a
16. b
17. a
18. d
19. c
20. a
21. a
22. d
23. b

CHAPTER 3

ELECTRICITY FOR THE GUNNER'S MATE

1. b
2. d
3. a
4. b
5. c
6. c
7. a
8. c
9. d
10. d
11. a
12. b

CHAPTER 4

FIRE CONTROL

1. b
2. c
3. d
4. d
5. a
6. c
7. b
8. c
9. d
10. a

CHAPTER 5

SMOKELESS POWDER

1. d
2. a
3. c
4. c
5. False
6. False
7. True
8. False
9. True
10. (1) b
    (2) g
    (3) e
    (4) c
    (5) d
    (6) a
    (7) f
11. a
12. b
13. d
14. d
15. d
16. a
17. d
18. a
19. a
20. d

CHAPTER 6

HYDROSTATIC DEPTH CHARGES

1. c
2. a
3. c
4. b
5. d
6. a
7. a
8. d
9. b
10. a
11. b
12. c
13. a
14. d
15. d
16. b
17. 15 kts (plus or minus 1 kt)

CHAPTER 7

INFLUENCE-TYPE DEPTH CHARGES

1. c
2. d
3. b
4. c
5. d
6. a
7. c
8. a
9. d
10. d

CHAPTER 8

ROCKETS, LAUNCHERS, AND PROJECTORS

1. b
2. d
3. d
4. c
5. c
6. a
7. b
8. c
9. a
10. d
11. b
12. c
13. d
14. b
15. c
16. b

CHAPTER 9

MINES AND AIRCRAFT BOMBS

1. a. Bomb body
   b. Fuse or fuses
   c. Fin or tail assembly
   d. Arming wire assembly
2. b
3. a
4. b
5. d
6. d
7. d
8. b
9. c
10. d
11. b
12. c
13. a
14. c
15. a
16. d
17. b
18. d

CHAPTER 10

ORDNANCE SUPPLY

1. a
2. d
3. b
4. b
5. d
6. a
7. c
8. d
9. a
10. c

CHAPTER 11

DEMOLITION MATERIALS AND TECHNIQUES

1. b
2. a
3. b
4. d
5. a
6. d
7. d
8. c
9. b
10. c
11. c
12. a
13. c
14. d
15. b
16. a
17. c
18. a

CHAPTER 12

BATTERY ALIGNMENT

1. b
2. a
3. c
4. c
5. b
6. d
7. d
8. a
9. c
10. b
11. d
12. a
13. b
14. b
15. d

CHAPTER 13

SAFETY

1. b
2. a
3. d
4. d
5. c

APPENDIX II

QUALIFICATIONS FOR ADVANCEMENT IN RATING

GUNNER'S MATE (GM)

RATING CODE NO. 0600

General Service Rating

Gunner's Mates operate, maintain, overhaul, and repair small arms, rocket launchers, guns, mounts, and turrets; maintain, overhaul, and repair the various electrical, mechanical, and hydraulic systems in guns, mounts, turrets, hoists, and associated equipment; test and inspect, and supervise the handling and stowage of, ammunition and ammunition components; test and adjust electronic amplifiers of gun power-drive systems; inspect and maintain magazines and ammunition stowage spaces; test magazine sprinkler systems; operate and maintain depth charge mechanisms, projectors, and release mechanisms. When assigned to CB activities, usually serve as armorers.

Emergency Service Ratings

Title	Abbr.	Rating Code No.	Definition
Gunner's Mates M (Mounts)	GMM	0601	Maintain and repair small arms, rocket launchers, 5" guns and below, and associated equipment; supervise handling and stowage of ammunition and ammunition components; operate and maintain depth charge mechanisms, projectors, and release mechanisms.
Gunner's Mates T (Turrets)	GMT	0602	Operate, maintain, and repair large guns, turrets, and associated equipment, train and direct turret crews; test, inspect, and supervise handling and stowage of turret ammunition and ammunition components.
Gunner's Mates A (Armorers)	GMA	0603	Are usually assigned to CB activities as armorers. Store, issue, and repair field equipment such as small arms, packs, helmets, gas masks, and bayonets; instruct personnel in firing and field stripping small arms; assist mine and bomb disposal personnel in disarming unexploded mines, bombs. and projectiles.

Navy Job Classifications and Codes

For specific Navy job classifications included within this rating and the applicable job codes, see *Manual of Enlisted Navy Job Classifications*, NavPers 15105 (Revised), codes GM–0800 to GM–0999.

Qualifications for Advancement in Rating	APPLICABLE RATES			
	GM	GMM	GMT	GMA
100 PRACTICAL FACTORS				
101 OPERATIONAL				
1. Operate nonpower-driven rocket launchers and projectors if equipment is available	3	3	----	3
2. Stow and issue small arms, ammunition, and landing-party equipment	3	3	----	3
3. Operate hoists and associated equipment for ammunition supply in own battery	3	3	----	----
4. Operate line-throwing gun	3	3	----	----
5. Demonstrate ability to man all stations, excluding mount or gun captain, on light or heavy machine gun or dual purpose mount	3	3	----	----
6. Locate principal isolation (cut-out) valves and test-operate magazine sprinkler systems in own ship	3	3	----	----
7. Demonstrate method of resuscitating a man unconscious from electrical shock and treating for electrical burns	3	3	----	----
8. Demonstrate ability to operate or fire pyrotechnics and use associated equipment	2	2	----	2
9. Demonstrate use of own ship or station landing-party (infantry) equipment including small arms, weapons, and grenades	2	2	----	2
10. Operate power-driven rocket launchers and projectors if equipment is available	2	2	----	----
11. Demonstrate ability to act as a gun, mount, or rocket mount captain in a main, antiaircraft, or rocket battery	2	2	----	----
12. Demonstrate procedures for use of own ship's demolition equipment	2	2	----	----
13. Make two-dimensional sketches for job orders	1	1	1	1
14. Make ready for firing and operate depth charge battery on own ship	1	1	----	----
15. Demonstrate ability to man all stations and operate all equipment in turret to which assigned	1	----	1	----

Qualifications for Advancement in Rating	APPLICABLE RATES			
	GM	GMM	GMT	GMA
102 MAINTENANCE AND/OR REPAIR				
1. Solder electrical connections and watertight seams	3	3	----	3
2. Use drill press, electric and pneumatic power tools, bench grinders, bore and chamber gages, and special hand tools for ordnance equipment maintenance and repair	3	3	----	3
3. Field-strip, clean, lubricate, and reassemble small arms and light machine guns up to and including caliber .50	3	3	----	3
4. Make required inspections of magazines and ammunition	3	3	----	3
5. Clean, lubricate, and make operational tests on ordnance equipment to which assigned, following appropriate check-off lists	3	3	----	3
6. Locate ordnance lubrication fittings, using lubrication charts	3	3	----	----
7. Trace and identify symbols of a circuit on a firing and lighting wiring diagram	3	3	----	----
8. Cut, thread, and tin piping and tubing	3	3	----	----
9. Overhaul, repair, and adjust 20 mm or 40 mm gun mechanisms if equipment is available	3	3	----	----
10. Drain and fill hydraulic equipment	3	3	----	----
11. Make tests of firing and lighting circuits, using meggers and test lamps	3	3	----	----
12. Overhaul, repair, and adjust small arms and light machine guns up to and including caliber .50	2	2	----	2
13. Overhaul, repair, and adjust a breech mechanism on a gun not exceeding 5 inches	2	2	----	----
14. Overhaul, repair, and adjust nonpower-driven rocket launchers and projectors	2	2	----	2
15. Interpret mechanical and hydraulic schematic and ordnance drawings	2	2	----	----
16. Identify symbols and trace circuits on electrical schematics and wiring diagrams	2	2	----	----

Qualifications for Advancement in Rating	APPLICABLE RATES			
	GM	GMM	GMT	GMA
17. Use bore erosion gages	2	2	----	----
18. Boresight guns and make necessary adjustments to sight mechanisms	2	2	----	----
19. Test firing cut-out devices and mechanical fuse-setting devices for proper operation	2	2	----	----
20. Make electrical tests using voltmeters, ohmmeters, and multimeters, and perform authorized maintenance of gunnery electrical circuits in power and control equipment in mounts or turrets, and hoists, excluding internal maintenance of electronic components	1	1	1	----
21. Test, adjust, and make repairs to recoil, counterrecoil, and gas ejector systems	1	1	1	----
22. Overhaul, repair, and adjust power-driven rocket launchers and associated equipment if available	1	1	1	----
23. Conduct preparations of a gun or mount and associated equipment for firing	1	1	1	----
24. Prepare for firing and make shipboard tests of rocket, projector, and depth charge ammunition	1	1	----	----
25. Make operational adjustments, test inputs and outputs, and replace tubes in power-drive amplifiers	1	1	----	----
26. Overhaul, repair, and adjust all mechanical and hydraulic equipment in a turret or mount	C	C	C	----
27. Make casualty analysis and direct repair of all mechanical and hydraulic gun equipment	C	C	C	----
28. Test and adjust, and overhaul and repair, indicator and receiver regulator equipment used in hydraulic power-drive control systems	C	C	C	----
29. Conduct preparation of a battery or turret for firing	C	C	C	----

Qualifications for Advancement in Rating—Continued

Qualifications for Advancement in Rating	APPLICABLE RATES			
	GM	GMM	GMT	GMA
108 ADMINISTRATIVE AND/OR CLERICAL				
1. Record required information in battery and magazine logs	3	3	----	3
2. Train personnel in field-stripping and firing small arms	2	2	----	2
3. Prepare naval shipyard or tender work request or job order	2	2	----	----
4. Train battle station crews in operation, safety precautions, and casualty procedures of guns, mounts, or rocket mounts	2	2	----	----
5. Maintain supplies and spare parts and obtain replacements	1	1	1	1
6. Maintain ordnance histories	1	1	1	1
7. Train battle station crews in turret operation and safety precautions	1	----	1	----
8. Prepare reports required by the gunnery or ordnance department	C	C	C	C
9. Prepare loading and stowage plans for ammunition and ammunition components	C	C	C	C
10. Maintain a Current Ship's Maintenance Project (CSMP)	C	C	C	----
200 EXAMINATION SUBJECTS				
201 OPERATIONAL				
1. Methods of lighting, cooling, ventilating, and sprinkling magazines	3	3	----	3
2. Safety precautions to be observed in the handling and stowage of explosives	3	3	----	3
3. Color codes and markings used for projectile identification. Types of projectiles and projectile components	3	3	----	----
4. Methods of setting mechanical fuzes	3	3	----	----
5. Safety precautions applied to handling and firing of rocket ammunition from nonpower-driven rocket launchers	3	3	----	3

Qualifications for Advancement in Rating—Continued

Qualifications for Advancement in Rating	APPLICABLE RATES GM	 GMM	 GMT	 GMA
6. Principles of function and purpose of firing cut-out devices	2	2	----	----
7. Characteristics of projectiles, projectile components, bursting charges, propellants, primers, fuses, and ship pyrotechnics	2	2	----	----
8. Principles of operation of amplidyne motors and generators used in mount power drives	1	1	1	----
9. Characteristics of gun, rocket, projector, and depth charge ammunition	1	1	1	----
10. Methods of installing pistols and launching depth charges. Depth charge safety precautions	1	1	----	----
202 MAINTENANCE AND/OR REPAIR				
1. Soldering methods and materials used for electrical connections	3	3	----	3
2. Information obtained from lubrication charts and precautions to be observed in lubricating ordnance equipment	3	3	----	3
3. Construction and operating principles of .45-caliber pistol and .30-caliber M1 rifle	3	3	----	3
4. Application and principles of operation of cams, gear trains, levers and mechanical linkages, pulleys, chains and sprockets, screws, clutches, springs, universal joints, and bearings	3	3	----	3
5. Methods and equipment used in electrical tests for continuity, grounds, and short circuits	3	3	----	----
6. Types, uses, and care of fittings, gaskets, and packing used in ordnance hydraulic systems	3	3	----	----
7. Operating principles of small arms and light machine guns used by the Navy	----	----	----	3
8. Tests and inspections required for ammunition and ammunition components and explosives	2	2	----	2

Qualifications for Advancement in Rating	APPLICABLE RATES			
	GM	GMM	GMT	GMA
9. Types of information shown on mechanical, electrical, and hydraulic schematics, ordnance drawings, and wiring diagrams	2	2	----	----
10. Purpose and methods of boresighting guns	2	2	----	----
11. Purpose of bore erosion gages	2	2	----	----
12. Principles of operation of breech and firing mechanisms	2	2	----	----
13. Applications and principles of operation of check, needle, and spool valves; Bourdon gages; gear, vane, and axial piston pumps and motors; work cylinders; and accumulators. Knowledge of the differential area principle and the distinction between simple and compound valves	2	2	----	----
14. Principles of operation and purpose of recoil and counterrecoil systems. Purpose of gas ejector systems	2	2	----	----
15. Construction of small arms and light machine guns	----	----	----	2
16. Types and construction of small arms ammunition	2	2	----	2
17. Purpose and application of voltmeters, ohmmeters, and multimeters	1	1	1	----
18. Functional relationships of components of ordnance hydraulic systems	1	1	1	----
19. Method of plotting a firing cut-out cam	1	1	1	----
20. Methods and purpose of battery alinement afloat	1	1	1	----
21. Operating principles of rocket motors and arming of rocket fuzes	1	1	----	----
22. Types and characteristics of construction explosives used in CB activities and safety precautions for their handling and stowage	----	----	----	1
23. Purpose and method of conducting surveillance tests of smokeless powder	C	C	C	----

Qualifications for Advancement in Rating	APPLICABLE RATES			
	GM	GMM	GMT	GMA
24. Characteristics and use of indicator and receiver regulator synchros and methods of setting to electrical zero	C	C	C	----
25. Method and purpose of star gaging	C	C	C	----
203 Administrative and/or Clerical				
1. Purposes and types of entries made in battery and magazine logs	3	3	----	3
2. Type of information found in OP's	3	3	----	3
3. Functions of various companies of a Construction Battalion	----	----	----	3
4. Procedures for requisitioning spare parts and standard stock items	1	1	1	1
5. Uses made of, and information found in, NavOrd OD 3000	1	1	1	1
6. Purposes and types of entries made in ordnance histories	1	1	1	----
7. Types of information found in the following publications: OD, OP, OCL, OHI, OML, ORDALTS, and BuOrd Instructions and Notices	C	C	C	C
8. Purpose and scope of the BuOrd Manual as stated in chapter 1	C	C	C	C
9. Types of reports required by the Bureau of Ordnance concerning guns, mounts or turrets, and ammunition	C	C	C	C
10. Information shown in Current Ship's Maintenance Project (CSMP)	C	C	C	C

300 NORMAL PATH OF ADVANCEMENT TO WARRANT GRADE

Gunner's Mates advance to GUNNERS 723 (SURFACE ORDNANCE TECHNICIANS) who generally serve as assistants to the gunnery officer or are otherwise assigned ordnance duties.

INDEX

NOTE: All references in this index, whether they concern text material or illustrations, are to page numbers. No references are made to illustrations by their own numbers. Fold-in illustrations have no page numbers; the index, therefore, refers to them by the numbers of the pages they face.

In general, all items of ordnance equipment that bear Mk, Mod, or AN numbers may appear in this index in three ways: (1) by the name of the equipment—for example: Rocket head Mk 1, 12.75-inch; (2) by Mk or AN number—for example: Mk 1 rocket head, 12.75-inch; (3) by caliber (where applicable)—for example: 12.75-inch rocket head Mk 1. You can, therefore, find the reference to any ordnance equipment taken up in this course by looking it up in any one of these three ways. Entries that begin with numbers are located alphabetically as if the numbers were spelled out. (Therefore, you will find 12.75 . . . . among the T's.)

The same principle applies to NavOrd publications, which are listed both by title, and by number and letter or abbreviation prefix. NavPers publications, however, are indexed by title only.

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